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INVESTIGATION OF TOTAL BOD_5 VERSUS CARBONACEOUS BOD_5 AS A MONITORING PARAMETER FOR SEWAGE TREATMENT WORKS PERFORMANCE AND COMPLIANCE

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EXECUTIVE SUMMARY

The 5-day biochemical oxygen demand (BOD_5) is currently used as one of the parameters to determine the operating efficiencies of sewage treatment plants (STP) and the quality of their effluents. The BOD_5 test measures the oxygen utilized in a 5-day period for the biochemical degradation of organic material (carbonaceous biochemical oxygen demand, $CBOD_5$) and may also measure the oxygen used to oxidize reduced forms of nitrogen, such as ammonia and nitrites, (nitrogenous oxygen demand) unless their oxidation is prevented by an inhibitor. If the test measures both these demands, then the total biochemical oxygen demand measured is known as $TBOD_5$ (or simply, as BOD_5).

Significant nitrogenous oxygen demand can be exerted when sufficient numbers of nitrifying bacteria and ammonia (or nitrites) are present in the test sample. In other words, the effluents from STPs exhibiting partial nitrification may have higher values from the BOD_5 testing than those with no or complete nitrification. Since most factors that are conducive to improved effluent quality from secondary STPs are also conducive to nitrification, the effluent BOD_5 values can erroneously indicate poorer quality when, in fact, both the effluent quality and the plant performance have improved. This is often the case in newer secondary treatment plants that are organically underloaded.

In order to reduce their BOD_5 values to meet their compliance requirements, some operators may try to operate their plants in a mode that suppresses nitrification when they are not required to meet any ammonia compliance criteria. This practice usually results in increased effluent toxicity and oxygen demand on the receiving water bodies, thereby causing detrimental effects to the environment. This undesired situation can be eliminated if $CBOD_5$ is used in the limit setting process for STP compliance.

The limits for STP effluent parameters are usually set based on historical plant performance data (as in the Ministry policies such as policy 08-01) or based on receiving water quality criteria. Since the historical data for organic removal performance of STPs are, for the most part, in terms of $TBOD_5$, it poses a problem in setting a $CBOD_5$ limit that is both achievable and not result in any relaxation in the current levels of treatment mandated for treatment facilities.

To better understand the relationship (if any) between the $CBOD_5$ and $TBOD_5$, and any other parameters that may influence this relationship, the Ministry of Environment and Energy initiated this study, covering all four seasons, in which effluents from 23 STPs exhibiting various degrees of nitrification were tested for $TBOD_5$ and $CBOD_5$.

The nitrogen parameters TKN, total ammonia-N, nitrites-N and nitrites plus nitrates-N were also monitored in the actual BOD test bottles initially and after 5 days of incubation.

Based on the study, it is recommended that $CBOD_5$ should be used for the measurement of secondary sewage treatment works performance and as an indicator of their effluent quality. In cases where the nitrogenous oxygen demand in the receiving water body is of concern, the effluent quality from the treatment facilities should be monitored using either TKN or total ammonia nitrogen. (Unionized ammonia nitrogen concentrations should be limited if effluent ammonia toxicity is of concern in the receiving water body). It was also concluded that an extensive $CBOD_5$ data base should be established in order to set a defensible $CBOD_5$ limit as a minimum secondary treatment requirement. In the interim, a $CBOD_5$ limit of 25 mg/L is reasonable.

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The sampling for the study was coordinated by Mr. I.G. (Gus) Perkons (MOEE West Central Region), Ms. Cynthia Levesque (MOEE Central Region) and Mr. Gareth Mongrain (MOEE Mid-Ontario Region). The sample analysis was coordinated by Mr. Francis B. Lo of the MOEE Laboratory Services Branch. The statistical analysis for the study was carried out by Dr. Jega Selliah of the MOEE Monitoring and Reporting Branch.

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Mr. G. Perkons	West Central Region, MOEE
Mr. J. Timko	Central Region, MOEE

1. INTRODUCTION

The 5-day, biochemical oxygen demand (BOD_5) test measures the oxygen utilized during a 5-day period for the biochemical degradation of organic material (carbonaceous oxygen demand) and the oxygen used to oxidize inorganic material such as sulfides and ferrous iron (APHA, 1989). Significant nitrogenous oxygen demand (NOD) can be exerted during BOD_5 testing when sufficient population of nitrifying bacteria, ammonia and/or nitrites are present in the test samples with low organic content. Unless complete nitrification is achieved, the amount of NOD exerted during the BOD testing is limited by the amount of nitrifying bacteria rather than by the ammonia and/or nitrite concentrations present in the sample. The amount of nitrifying bacteria present inside the BOD bottles during the test can be affected by many factors such as effluent quality, sample preservation conditions during transit and the amount of dilution used during the test. Consequently, the occurrence and the extent of NOD are both erratic and unpredictable under the conditions of the BOD test (Barth, 1981).

If only the carbonaceous oxygen demand is measured, the test results are referred to as $CBOD_5$. The oxygen demand exerted by the oxidation of inorganic material in domestic wastewaters is usually not significant. If both $CBOD_5$ and NOD are measured, the resulting oxygen demand is defined as total biochemical oxygen demand ($TBOD_5$). Unfortunately, the term BOD_5 was never explicitly defined to mean $CBOD_5$ or $TBOD_5$ until the 17th edition of the Standard Methods was published in 1989. The Standard Methods now defines $TBOD_5$ as BOD_5, and $CBOD_5$ as the oxygen demand measured when the exertion of NOD is inhibited during the testing.

Several STP operating authorities and consulting engineers have expressed their concerns to the Ministry of Environment and Energy (MOEE) about the use of $TBOD_5$ for assessing STP effluent compliance. They argued that many STPs are unable to meet the $TBOD_5$ effluent limits when the plants are operated efficiently and produce a nitrified effluent. This condition is particularly prevalent in treatment plants required to partially nitrify their effluents (to protect the receiving water body from ammonia toxicity) and in plants where the organic loadings to their aeration tanks are significantly lower than their designed loadings. The MOEE staff are also aware of this situation in some treatment facilities. These situations are illustrated by the United States Environmental Protection Agency (US EPA) using an example, as illustrated in Table 1.1.

In this case, although Plant C is discharging the best quality effluent, the $TBOD_5$ results indicate that it produces the "poorest" effluent quality. This is due to the establishment of a large population of nitrifying bacteria in the facility (and therefore, through the effluent into the BOD test bottles) since it is operating only at half the design capacity. Also, based on the $TBOD_5$ results, Plant B appears to be discharging a greater load of oxygen demanding materials than Plant A, even though the ultimate oxygen demand (UOD = 1.5 x $CBOD_5$ + 4.6 x total ammonia-N) effluent quality of the two facilities are identical.

Table 1.1 Effects of Effluent Characteristics on $TBOD_5$

Plant	% Design Flow	Amount of Nitrifiers in sample	$CBOD_5$ (mg/L)	Total Ammonia N (mg/L)	UOD (mg/L)	$TBOD_5$ (mg/L)
A	100	Insignificant	25	18	120	30
B	80	Moderate	25	18	120	35
C	50	Very Large	10	10	61	45

However, the MOEE has also received concerns from some water quality scientists, questioning whether it is appropriate to steer away from the use of the $TBOD_5$ parameter which has been historically used. They argued that the $TBOD_5$ limit is set to protect the receiving waters from oxygen depletion, regardless of whether the oxygen depletion is caused by carbonaceous or nitrogenous oxygen demand. They also fear that the chemical used to inhibit nitrification during the testing may also affect the biochemical oxidation of the carbonaceous matter, thereby artificially lowering the oxygen demand. Furthermore, there is a lack of $CBOD_5$ database in Ontario to allow limits to be set on $CBOD_5$.

1.1 SCOPE AND OBJECTIVES OF THE STUDY

In order to resolve the issue of whether $TBOD_5$ or $CBOD_5$ is a more appropriate parameter for effluent limit setting and compliance assessment, the present study was initiated by MOEE in August, 1991. The specific objectives of the study are as follows:

(a) To review published research literature on the issue of $TBOD_5$ versus $CBOD_5$;

(b) To review information on how the U.S. EPA handled this issue;

(c) To investigate the factors that affect the relationship between $TBOD_5$ and $CBOD_5$, if any; and,

(d) To develop a correction factor(s) to allow the use of the historical $TBOD_5$ data to set $CBOD_5$ based effluent limits.

2. STUDY METHODS

Historical data were used to select 23 STPs exhibiting various degrees of nitrification. For logistic reasons, all 23 STPs are located in southern Ontario. The names of the plants are given in Appendix. The final effluent samples collected at the STPs were shipped immediately to the MOEE laboratory in Toronto. Analysis was carried out within two days after the sample collection.

Each sample was tested for both $TBOD_5$ and $CBOD_5$. TCMP [2-chloro-6(trichloro methyl) pyridine] was used as the inhibitor during the $CBOD_5$ testing and was added at the laboratory prior to the analysis. Total ammonia-N, TKN, nitrite-N and nitrite plus nitrate-N were monitored in the BOD bottles at the beginning and after 5 days of incubation. The analysis results are presented in Appendix.

Depending on the accessibility of final effluent discharge and whether the plants were practising effluent chlorination or not, chlorinated or unchlorinated samples were collected. In limited cases, both chlorinated and unchlorinated samples were taken. The results from these samples were used to investigate whether chlorination has any effects on the relationship between $TBOD_5$ and $CBOD_5$.

The study covered all four seasons and sampling was carried out in May 1992, August 1992, November 1992 and February 1993. The results from these sampling periods will be referred to as the spring, summer, fall and winter data respectively.

3. LITERATURE REVIEW

3.1 NOD Interferences in BOD_5 Test

The effect of nitrification during the standard BOD_5 test was first reported in 1946 (Sawyer and Bradney, 1946; Ruchhoft et al. 1948). Sawyer and Bradney observed that the BOD_5 removal achieved at an activated sludge/trickling filter plant fluctuated widely. On some occasions, even negative BOD_5 removals were observed. As part of the investigation into the causes of this erratic BOD_5 removal, Sawyer and Bradney measured the BOD_5 of the plant's partially nitrified effluent, using two dilutions: 10% sample (low dilution) and 5% sample (high dilution). The results from this testing are given in Table 3.1.

Table 3.1 Variations in BOD of Effluent (Sawyer and Bradney, 1946)

Date	5-day BOD (mg/L)	
	Low dilution (10% sample)	High dilution (5% sample)
Jan.27/45	54	42
Jan.28/45	27	17
Jan.29/45	69	46
Jan.30/45	65	53
Jan.31/45	68	50
Feb.1/45	38	23
Feb.2/45	47	29
Feb.3/45	63	26
Feb.4/45	18	9
Feb.5/45	63	25
Average	**51**	**32**

It shows that the low dilution samples yielded an average BOD_5 concentration of 51 mg/L while the high dilution samples yielded an average BOD_5 concentration of 32 mg/L.

They then repeated the same test using a primary effluent taken from a domestic wastewater treatment plant. The results (Table 3.2) show that the average BOD_5 concentrations in the low and high dilution samples were essentially the same at 152 mg/L and 153 mg/L, respectively. Based on these results, Sawyer and Bradney concluded that the reduced BOD_5 values obtained with increased dilution were due to the decrease in the population of nitrifying bacteria in the BOD bottles at the higher dilutions. Since the primary effluent did not contain significant nitrifying population, the amount of nitrifying bacteria in the BOD bottles at the two dilutions were not large enough to exert significant NOD during the tests. The high organic content of the primary effluent sample would also have slowed the nitrification process during the BOD_5 test through heterotrophic competition.

Table 3.2 Variations in BOD of Settled Domestic Wastewater (Sawyer and Bradney, 1946)

Date	5-day BOD (mg/L)	
	Low dilution (10% sample)	High dilution (5% sample)
Feb.8/45	153	133
Feb.9/45	100	135
Feb.12/45	153	147
Feb.13/45	133	140
Feb.14/45	107	100
Feb.15/45	153	146
Feb.16/45	187	186
Feb.17/45	190	186
Feb.19/45	184	180
Feb.20/45	163	173
Average	**152**	**153**

Sawyer and Bradney further confirmed the effects of nitrification in the BOD bottles by dividing a partially nitrified effluent sample into two batches. They pasteurized one batch and then re-seeded it with a population of microorganisms that did not contain significant population of nitrifying bacteria. The other batch was analyzed without pasteurization. Each batch of sample was then analyzed at the same two dilutions as previously used. The results (Table 3.3) show that the unpasteurized samples exhibiting a large difference in BOD_5 concentrations between the low and the high dilutions: 108 mg/L versus 60 mg/L, respectively. The pasteurized samples, on the

other hand, did not show any significant difference between the low and the high dilutions: 25 mg/L versus 23 mg/L.

Table 3.3 Effect of Effluent Pasteurization on BOD (Sawyer and Bradney, 1946)

Date	5-day BOD (mg/L)			
	Unpasteurized		Pasteurized	
	Low dilution	High dilution	Low dilution	High dilution
Mar.24/45	124	88	28	28
Mar.25/45	63	48	18	16
Mar.26/45	110	44	20	20
Mar.27/45	126	52	22	20
Mar.28/45	80	40	34	24
Mar.29/45	126	72	22	24
Mar.30/45	124	76	30	32
Average	**108**	**60**	**25**	**23**

DeMarco et al. (1967) studied the effects of initial concentrations of nitrifying bacteria and ammonia on the nitrification rates during the BOD testing. Their results are depicted in Figures 3.1 and 3.2. Figure 3.1 shows that the time taken to completely oxidize an initial concentration of 10 mg/L of ammonia was decreased from 7 days to 4 days when the initial concentration of the seed organisms which contained significant nitrifying bacteria was increased from 5 mg/L as VSS to 25 mg/L as VSS. These results imply that as the population of nitrifying bacteria in a sewage treatment plant effluent increases, the $TBOD_5$ concentrations would also increase. Figure 3.2 shows that as long as there is sufficient ammonia remaining, the rate of nitrification remains constant irrespective of the ammonia concentration.

In separate reviews, both Barth (1981) and Dague (1981) came to the same conclusion that the occurrence and the extent of NOD in the BOD_5 bottle is both erratic and unpredictable. Dague also concluded that DeMarco's results confirmed the conclusions made by Sawyer and Bradney that the extent of NOD interference in BOD_5 test is affected by the amount of nitrifying bacteria initially present in the BOD bottle and not by the ammonia concentration. Dague further suggested that the carbonaceous and nitrogenous oxygen demands be measured separately when monitoring STP performance.

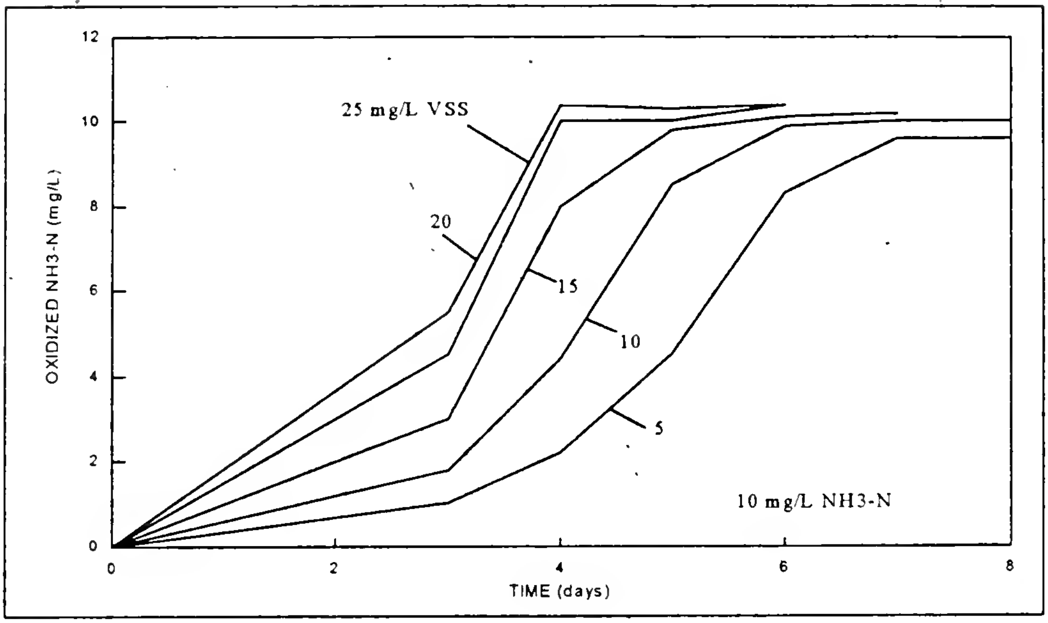


Figure 3.1 Influence of Seed Variation on Nitrification (DeMarco et al., 1967)

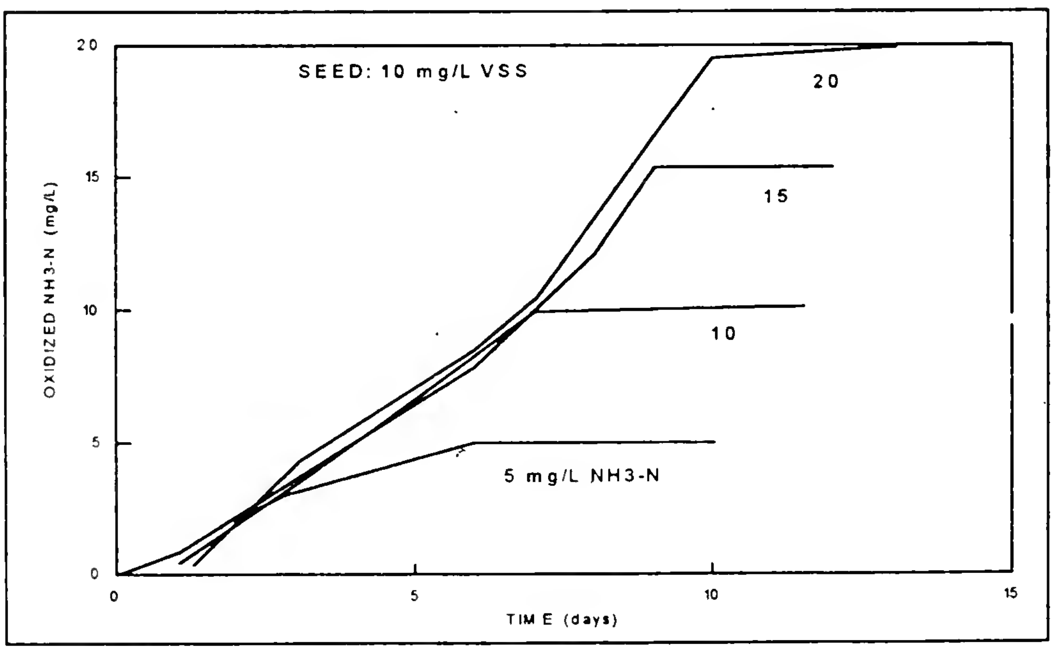


Figure 3.2 Influence in Variation in Ammonia Concentration on Nitrification (DeMarco et al., 1967)

3.2 Inhibition of NOD in the BOD_5 Test

Several methods such as pasteurization, chlorination, acid treatment and the addition of a chemical inhibiting agent can be used to eliminate NOD interference during the BOD_5 testing (Metcalf and Eddy, 1991). For simplicity, the use of a chemical inhibitor is preferred. Although many inhibiting agents such as thiourea, allylthiourea (ATU), 2-chloro-6(trichloro methyl) pyridine (TCMP) and other proprietary products are available (Young, 1973), the use of TCMP is recommended by the latest edition of the Standard Methods (APHA, 1989).

TCMP inhibits the conversion of ammonia-N to nitrite-N, but does not inhibit the second step in the nitrification process where nitrite-N is oxidized to nitrate-N. A survey by the U.S. EPA showed that virtually all municipal wastewater treatment plant effluents contained little or no nitrite. This is because the second step is not a rate limiting step in the nitrification process.

A study conducted by the MOEE Laboratory Services Branch (Cheung, 1992) also supports the use of TCMP as a nitrification inhibiting agent for the $CBOD_5$ test. Based on an extensive literature review, the U.S. EPA categorically dismissed the concerns expressed by some that TCMP may also affect the oxidation of carbonaceous matter during the 5-day test period.

3.3 "Standards Methods" Position on BOD_5

The 16th edition of the Standard Methods (APHA, 1985) states that "the inclusion of ammonia (as NH_4Cl) in the dilution water demonstrates that there is no intent to include the oxygen demand of reduced nitrogen forms in the BOD test", however small this demand may be. Also, the reference standard suggested for the calibration of the BOD_5 test is calculated on the basis of carbonaceous content of the reference chemical.

The 17th edition of the Standard Method (APHA, 1989) states that measurements that include NOD generally are not useful for assessing the oxygen demand associated with organic material. To eliminate the oxidation of nitrogenous compounds in the BOD test, the Standard Methods recommends that inhibition of nitrification during the test be practised for samples of secondary effluent, samples seeded with secondary effluent and samples of polluted waters. The results are to be reported as $CBOD_5$ when NOD is inhibited; otherwise results are reported as BOD_5.

4. U.S. EPA POSITION ON BOD_5

Realizing that the uninhibited BOD_5 test may give erratic or misleadingly high 5-day biochemical oxygen demand when nitrification or incipient nitrification occurs in a treatment facility, the U.S. EPA, in 1984, accepted the use of $CBOD_5$, as an alternative to $TBOD_5$, for setting effluent limits. It set an effluent standard of 25 mg/L for $CBOD_5$ as equivalent to its standard of 30 mg/L of $TBOD_5$ for secondary treatment (U.S. EPA, 1984). The 5 mg/L difference was based on a statistical analysis of $TBOD_5$ and $CBOD_5$ results obtained in paired samples taken from 26 secondary STPs.

The study was conducted only during cool weather conditions, when nitrification was minimal. The Agency maintained that because nitrification or incipient nitrification may occur during warmer weather conditions, there would be little or no correlation between BOD_5 and $CBOD_5$ data. Also, the secondary treatment standards are based on the performance achievable during the cool weather conditions when the biological activity is at its lowest rate.

Several people have expressed concerns regarding the U.S. EPA decision to allow effluent limits be set on $CBOD_5$. They argued that $CBOD_5$ ignores the major oxygen demand exerted by the ammonia remaining in the effluent on the receiving water bodies. The U.S. EPA repelled the argument. It stated, in its judgement, that the NOD exerted in the receiving waters depends on the characteristics of the receivers more so than the ammonia concentration in the final effluent. Low NOD was observed in many waters under certain conditions of temperatures and dilutions afforded to the discharges. Little or no NOD was observed in some waters under all conditions. EPA concluded that the requirement to reduce NOD should be determined on a case-by-case basis, based on the receiving water characteristics. If NOD reduction is warranted, treatment more stringent than secondary should be installed, and an appropriate ammonia or TKN limit should be incorporated into the compliance permit of the plant.

Some of the other concerns raised by various people and the EPA's responses are listed below:

(a) Concern: The chemical used in the $CBOD_5$ testing to inhibit nitrification may also affect the carbonaceous oxidation reaction as well.

Response: The Agency cannot concur because the preponderance of the available research literature conclusively shows that the chemical used for inhibiting nitrification, TCMP, does not significantly affect the carbonaceous oxidation reaction during the 5-day test period.

(b) Concern: TCMP does not inhibit the conversion of nitrite to nitrate and therefore, the use of the $CBOD_5$ test procedure does not indicate the true $CBOD_5$ for wastewaters where nitrite is present.

Response: Virtually all the municipal wastewater data reviewed by the agency indicated little or no nitrite was present in nitrified effluents. For this reason the Agency believes a change or delay in implementing the $CBOD_5$ provisions of the secondary treatment regulation is not warranted.

(c) Concern: The inhibited test is needed to measure $CBOD_5$ only if a facility's effluent is partially nitrified. Well designed and operated facilities which nitrify should achieve complete nitrification, thereby eliminating ammonia that could affect the uninhibited test (i.e. $TBOD_5$) results.

Response: The Agency cannot concur with this line of reasoning because even when "complete nitrification" occurs, the remaining ammonia and the nitrifying bacteria in the effluent sample in combination with the ammonia from the test dilution water can measurably affect the $TBOD_5$ results.

Furthermore, the Agency is also aware that some treatment facilities are being intentionally operated in a mode that inhibits the growth of nitrifying bacteria to improve $TBOD_5$ test results and show compliance with secondary treatment requirements. These procedures usually result in poorer effluent quality (although $TBOD_5$ test results may indicate the opposite) and may often result in greater sludge production and higher operation and maintenance costs. The Agency believes that the implementation of $CBOD_5$ test procedures should eliminate this counter-productive operating practices since incidental nitrification will no longer affect the compliance test results.

Based on this extensive investigation into the issue of $TBOD_5$ versus $CBOD_5$, the US EPA concluded that it believes that the $CBOD_5$ is the most appropriate and relevant parameter for measuring the level of effluent quality and treatment performance of the secondary STPs. Although the $TBOD_5$ results may approximate the $CBOD_5$ parameter in many situations, particularly in cold weather, the exertion of a significant NOD in the test results for the $TBOD_5$ parameter in other cases will result in the reporting of a misleading value for a well performing secondary treatment facility. Since the degree of NOD in the $TBOD_5$ test cannot be determined without running a parallel $CBOD_5$ test or test for the presence of nitrifying bacteria, the use of the $CBOD_5$ parameter is recommended to ensure application of a meaningful effluent criteria for STPs providing secondary treatment.

5.1 Correlation between $TBOD_5$ and Ammonia

A scatter plot of $TBOD_5$ versus ammonia concentration for the data collected during all sampling periods is presented in Figure 5.1.

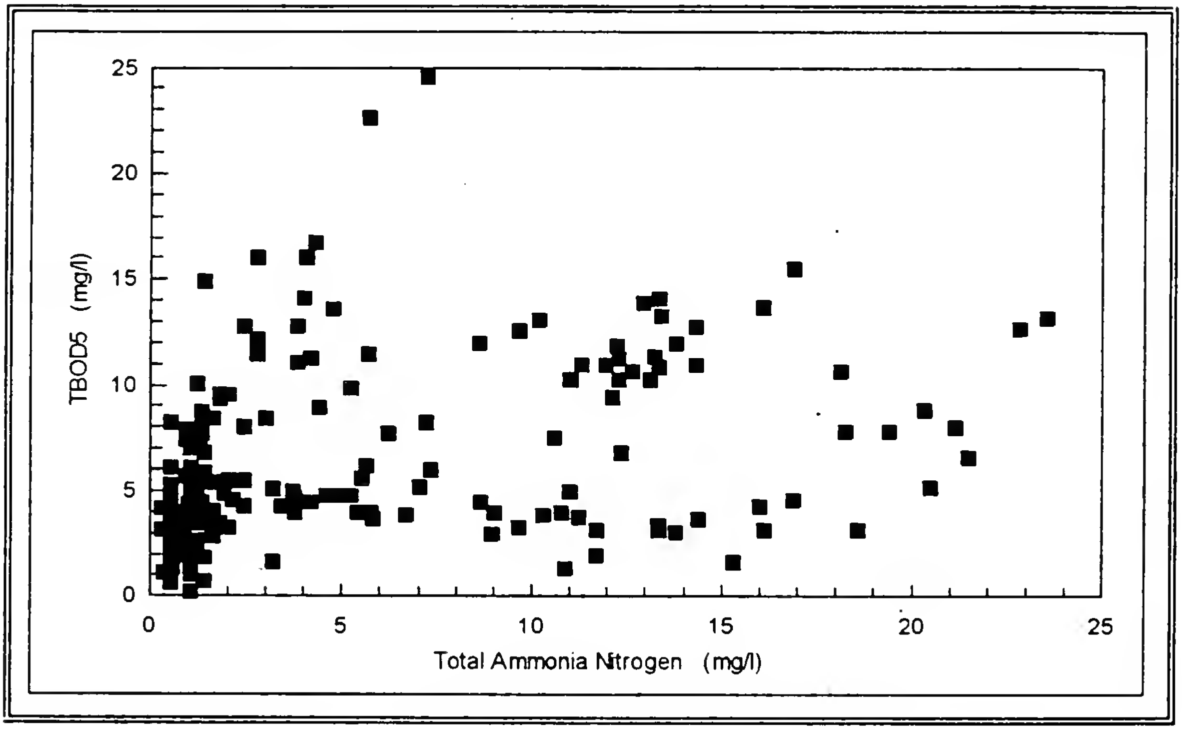


Figure 5.1 Plot of $TBOD_5$ versus Total Ammonia-N during All Seasons (R^2 = 0.14)

The large scatterness as indicated by the very low correlation (R^2 = 0.14) between $TBOD_5$ and ammonia supports the literature and the U.S. EPA's conclusions that NOD in BOD tests is erratic and unpredictable and that the reliance on $TBOD_5$ to protect the receiving waters against the NOD exerted by ammonia in the discharges is not justified.

5.2 Quantification of NOD in BOD_5 Test

Nitrification is a two step process. Ammonia-nitrogen (NH_3-N) and/or ammonium-nitrogen (NH_4^+-N) is first oxidized to nitrite-nitrogen (NO_2^--N) by *Nitrosomonas* bacteria, followed by the oxidation of NO_2^--N to nitrate nitrogen (NO_3^--N) by *Nitrobacter* bacteria. These two steps can be represented by Equations (1) and (2) as follows:

$$NH_3 \text{ (or } NH_4^+) + 1.5\, O_2 \rightarrow (2)\, H^+ + H_2O + NO_2^- \qquad \text{(Equation 1)}$$

$$NO_2^- + 0.5\, O_2 \rightarrow NO_3^- \qquad \text{(Equation 2)}$$

According to Equation (1), 3.43 mg of oxygen is necessary to convert 1 mg of NH_3-N to 1 mg of NO_2^--N (Alexander, 1964). However, due to CO_2 fixation by the autotrophic nitrifying bacteria, only 3.23 mg of oxygen would be required to convert 1 mg of NH_3-N to 1 mg of NO_2^--N (Velz, 1970; Montgomery and Borne, 1966). Similarly according to Equation (2), 1.14 mg of oxygen is required to oxidize 1 mg of NO_2^--N to 1 mg of NO_3^--N. The actual oxygen demand is reduced to 1.12 mg when CO_2 fixation is taken into account. By combining Equations (1) and (2) it is estimated that 4.35 mg (=3.23 mg + 1.12 mg) of oxygen is required to form 1 mg of NO_3^--N from 1 mg of NH_3 (or NH_4^+-N) (Stamer et al., 1979).

To investigate whether the difference between the 5-day oxygen demands measured in the uninhibited sample ($TBOD_5$) and in the inhibited sample ($CBOD_5$) can be accounted for by the nitrogenous oxygen demand (NOD) exerted in the BOD bottles during the 5-day incubation period, the following data analysis was carried out:

Step I: Oxygen Demand for Nitrite Formation from Ammonia

As stated in the literature, TCMP inhibits only the formation of NO_2^--N from NH_3 in the BOD bottles during the inhibited test. It does not prevent NO_2^--N from oxidizing to NO_3^--N. Consequently, at the end of the 5-day incubation period, NO_2^--N concentration in the inhibited bottle will be lower than that in the uninhibited bottle. The difference between the two concentrations, *(NO_2^--N in the uninhibited sample - NO_2^--N in the inhibited sample on day 5)*, was the result of NO_2^--N formation from the oxidation of NH_3-N in the uninhibited BOD bottle.

Since 3.23 mg of oxygen is needed to produce 1 mg of NO_2^--N from NH_3-N, the oxygen demand for NO_2^--N formation in the $TBOD_5$ bottle (but was not converted to NO_3^--N) can be expressed as,

Oxygen demand for nitrite formation from ammonia in the $TBOD_5$ *bottle = 3.23*(Difference in* NO_2^--N *concentrations between the uninhibited and inhibited samples on day 5)*

(Equation 3)

Step II: Oxygen Demand for Nitrate Formation from Ammonia

Increase in NO_3^--N in uninhibited samples would have resulted from the complete oxidation of NH_3-N or from the oxidation of NO_2^--N initially present. However, the contribution from the latter will be the same in both uninhibited and inhibited samples since TCMP does not inhibit the oxidation of NO_2^--N to NO_3^--N. The contribution of NO_3^--N from NO_2^--N in the uninhibited bottle can be quantified using the amount of NO_2^--N oxidized to NO_3^--N in the inhibited bottle as equal to *(the decrease in* NO_2^--N *in inhibited sample between days 0 and 5)*. Consequently, the portion of NO_3^--N resulting from the oxidation of NH_3-N in the uninhibited bottle can be quantified as, *(Increase in* NO_3^--N *in uninhibited sample - Decrease in* NO_2^--N *in inhibited sample between days 0 and 5)*.

Since 4.35 mg of oxygen is needed to produce 1 mg of NO_3^--N from NH_3 (or NH_4^+)-N, the oxygen demand for NO_3^--N formation in the $TBOD_5$ bottle can be expressed as,

Oxygen demand for nitrate formation from ammonia = 4.35(Increase in* NO_3^--N *in uninhibited sample - Decrease in* NO_2^--N *in inhibited sample between days 0 and 5)*

(Equation 4)

Step III: Oxygen Demand for Nitrate Formation from Nitrite

It should be noted that the oxygen demand for NO_3^--N formation from NO_2^--N need not be considered since this reaction occurs during both the tests.

Step IV: Additional Oxygen Demand Exerted in $TBOD_5$ Test

Therefore, the additional NOD exerted in the $TBOD_5$ bottle, or the difference between the $TBOD_5$ and $CBOD_5$ values in the parallel samples, can be obtained by summing up the oxygen demands expressed by Equations (3) and (4) as shown below:

($TBOD_5$ - $CBOD_5$) = 3.23(Difference in* NO_2^--N *concentrations between the uninhibited and inhibited samples on day 5) + 4.35*(Increase in* NO_3^--N *in uninhibited sample - Decrease in* NO_2^--N *in inhibited sample between days 0 and 5)*

(Equation 5)

If the difference between $TBOD_5$ and $CBOD_5$ was indeed caused by the difference in NOD that occurred in the BOD bottles during the two tests, then the average difference between the calculated difference (using Equation 5) and the observed difference (ie, $TBOD_5$ measured in the uninhibited test - $CBOD_5$ measured in the inhibited test) would equal to zero or some acceptable accuracy. To test this hypothesis, (calculated difference - observed difference) for each pair of data collected during all four seasonal periods were calculated. The average differences in each period were then tested by the "student-t/signed rank tests at a significance level of 0.05".

Table 5.1. Results of Calculated vs Observed ($TBOD_5$-$CBOD_5$) Analysis

Absolute difference between calculated and observed difference between $TBOD_5$ & $CBOD_5$	Spring	Summer	Fall	Winter
Mean ($\bar{x}$)	1.74	1.32	1.74	2.27
Standard error ($s/\sqrt{n}$)	0.56	0.49	0.38	0.55
# of data points	51	40	52	50
Hypothesis that the absolute difference $\leq$ 1.5 mg/L	NR	NR	NR	NR
Hypothesis that the absolute difference = 0 mg/L	R	R	R	R

(R = Rejected NR = Not Rejected)

The results of this analysis (Table 5.1) indicate that the difference between the $TBOD_5$ concentrations as measured in the uninhibited test and the $CBOD_5$ concentrations as measured in the inhibited test can be accounted for by the NOD exerted in the BOD bottles to within an accuracy of 1.5 mg/L.

5.3 Relationship Between $TBOD_5$ and $CBOD_5$

The relationship between $TBOD_5$ and $CBOD_5$ is examined in this section, in order to allow the use of historical $TBOD_5$ data for setting effluent limits based on $CBOD_5$, if necessary. Ideally, the amount of nitrifying bacteria present in the effluent sample should be incorporated into any relationship between $TBOD_5$ and $CBOD_5$. As stated in the literature review section, the amount of NOD exerted in the BOD test, in most cases, is limited by the amount of nitrifying bacteria present. Unfortunately, the amount of nitrifying bacteria present is not available in the historical data base. More importantly, the amount of nitrifying bacteria present in the sample cannot be easily quantified. As a compromise, the data obtained in the spring and summer periods were partitioned into 3 groups based on the initial ammonia concentrations, as shown in Table 5.2, to relatively reflect the different levels of nitrifying populations expected.

Table 5.2 Degrees of Nitrification

Degrees of Nitrification	Effluent		Probable Limiting Factor for NOD in the BOD bottle
	Total ammonia-N (mg/L)	# of Nitrifiers Expected	
Complete Nitrification	Low (typically < 2)	High	Initial ammonia concentration
Partial Nitrification	High (typically 2-11)	Moderate to High	# of nitrifying bacteria
No Nitrification	High (typically > 11)	Low	# of nitrifying bacteria

The relationship between $TBOD_5$ and $CBOD_5$ in each group was then tested using various regression models. The regression analysis was limited to the parameters, $TBOD_5$, $CBOD_5$ and total NH_3-N. However, it should be noted that any relationship between $TBOD_5$ and $CBOD_5$ involving other parameters (such as total ammonia-N, TKN, NO_2^--N, NO_3^--N and NO_x^--N) will be of very limited use since the historical data base does not have these parameters analyzed simultaneously with the $TBOD_5$ analysis on the same effluent sample. The relationships between $TBOD_5$ and $CBOD_5$, as obtained through statistical regression modelling are given in Tables 5.3(a) - (e). These are also graphically presented in Figures 5.2 (a) - (e).

Table 5.3 Statistical Models for $TBOD_5$ vs $CBOD_5$ Relationship

(a) SPRING

Total NH_3-N range (mg/L)	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
< 2	$TBOD_5 = 0.06 + 1.19\ CBOD_5$	0.86	28
2 - 11	$TBOD_5 = 2.13 + 1.05\ CBOD_5$	0.62	10
> 11	$TBOD_5 = 4.41 + 0.92\ CBOD_5$	0.69	13
All data	$TBOD_5 = 0.61 + 1.28\ CBOD_5$	0.80	51

(b) SUMMER

Total NH_3-N range (mg/L)	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
< 2	$TBOD_5 = 2.38 + 0.81\ CBOD_5$	0.32	19
2 - 11	$TBOD_5 = 2.46 + 1.33\ CBOD_5$	0.13	9
> 11	$TBOD_5 = 0.12 + 2.04\ CBOD_5$	0.33	12
All data	$TBOD_5 = 2.54 + 1.03\ CBOD_5$	0.22	40

(c) FALL

Total NH_3-N range (mg/L)	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
< 2	$TBOD_5 = 1.60 + 0.96\ CBOD_5$	0.51	40
2 - 11	$TBOD_5 = 3.30 + 1.43\ CBOD_5$	0.31	9
> 11	$TBOD_5 = -0.06 + 3.93\ CBOD_5$	1.00	3
All data	$TBOD_5 = 1.61 + 1.25\ CBOD_5$	0.34	52

(d) WINTER

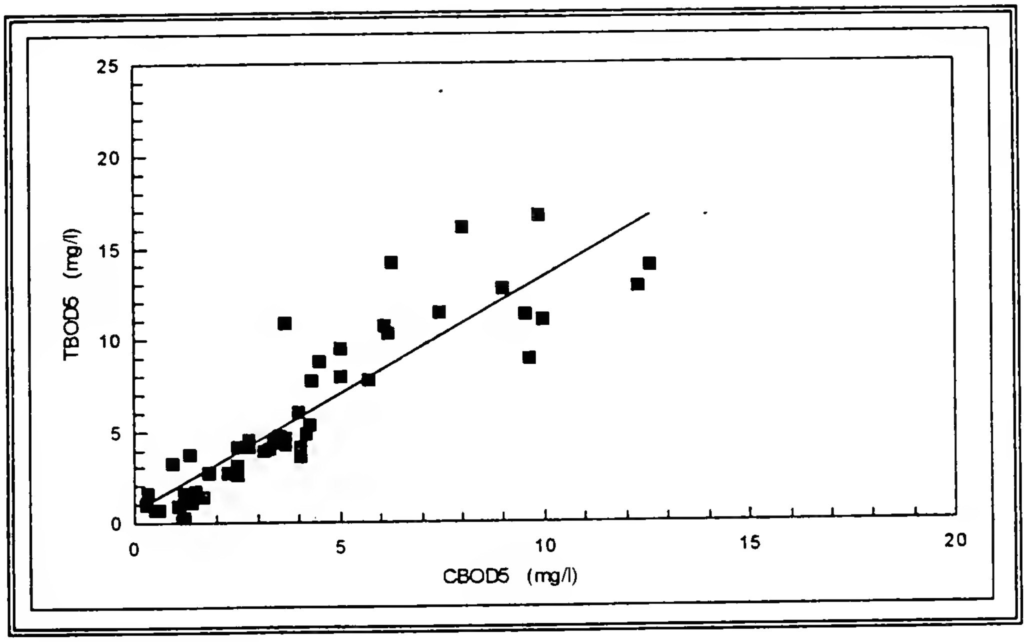
Total NH_3-N range (mg/L)	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
< 2	$TBOD_5 = 1.54 + 0.77\ CBOD_5$	0.92	10
2 - 11	$TBOD_5 = 1.79 + 1.06\ CBOD_5$	0.63	27
> 11	$TBOD_5 = 5.51 + 0.63\ CBOD_5$	0.36	13
All data	$TBOD_5 = 2.67 + 0.88\ CBOD_5$	0.59	50

(e) ALL YEAR

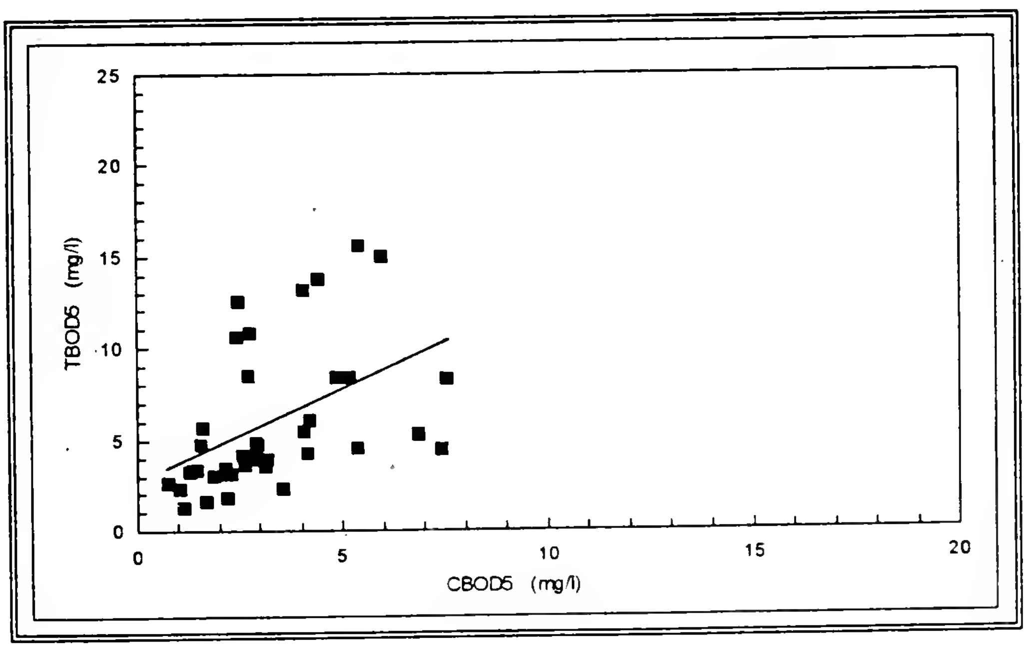
Total NH_3-N range (mg/L)	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
< 2	$TBOD_5 = 1.56 + 0.86\ CBOD_5$	0.62	97
2 - 11	$TBOD_5 = 2.82 + 1.01\ CBOD_5$	0.45	55
> 11	$TBOD_5 = 4.28 + 0.88\ CBOD_5$	0.41	41
All data	$TBOD_5 = 2.02 + 1.03\ CBOD_5$	0.53	193

Figure 5.2 **Plots of the Relationship between $TBOD_5$ and $CBOD_5$ during Different Seasons**

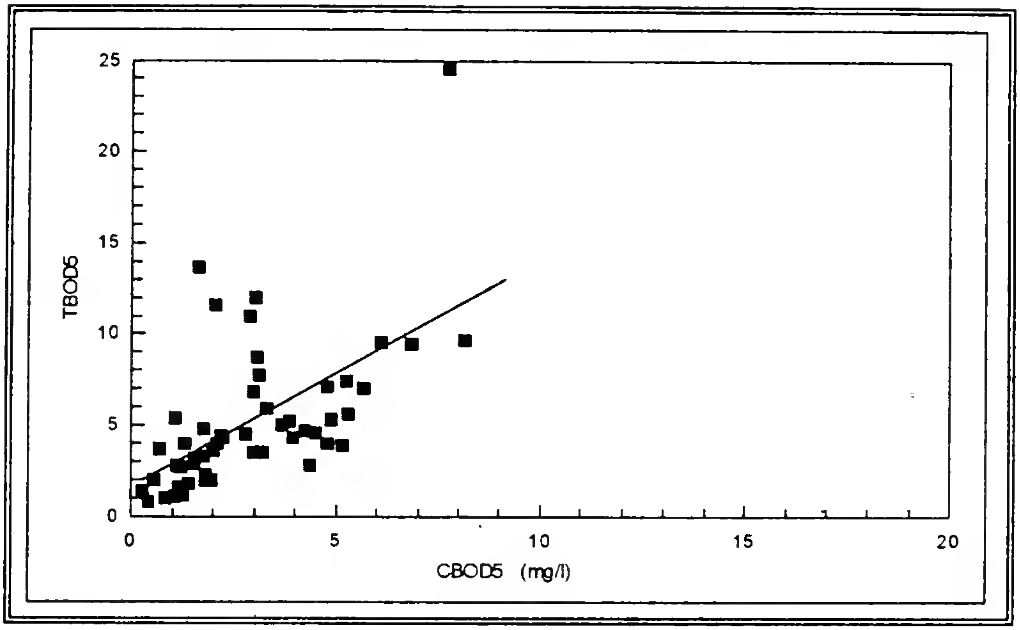
(a) **SPRING**



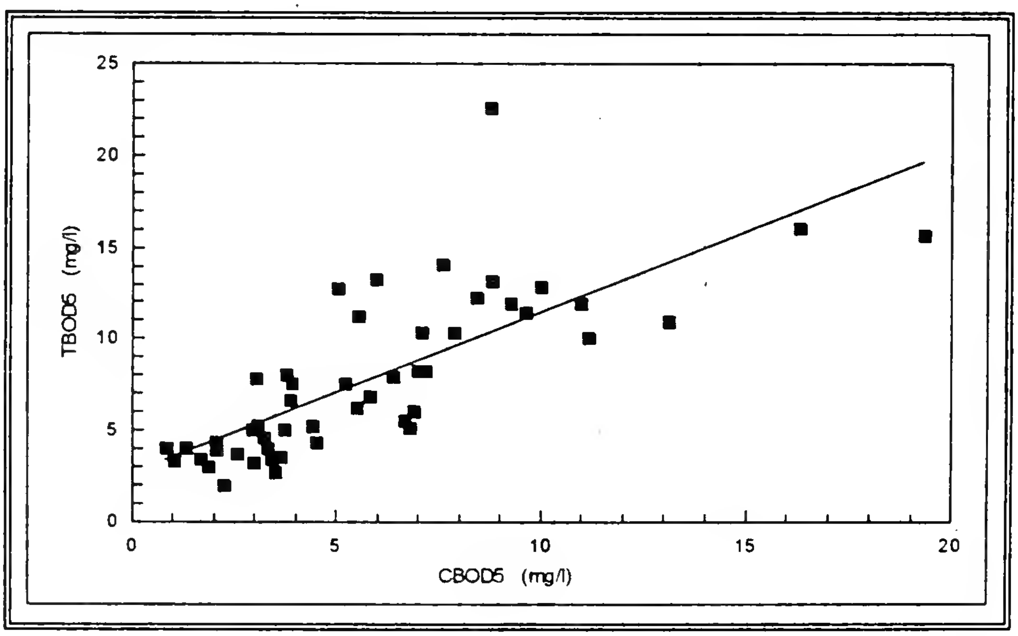
(b) **SUMMER**



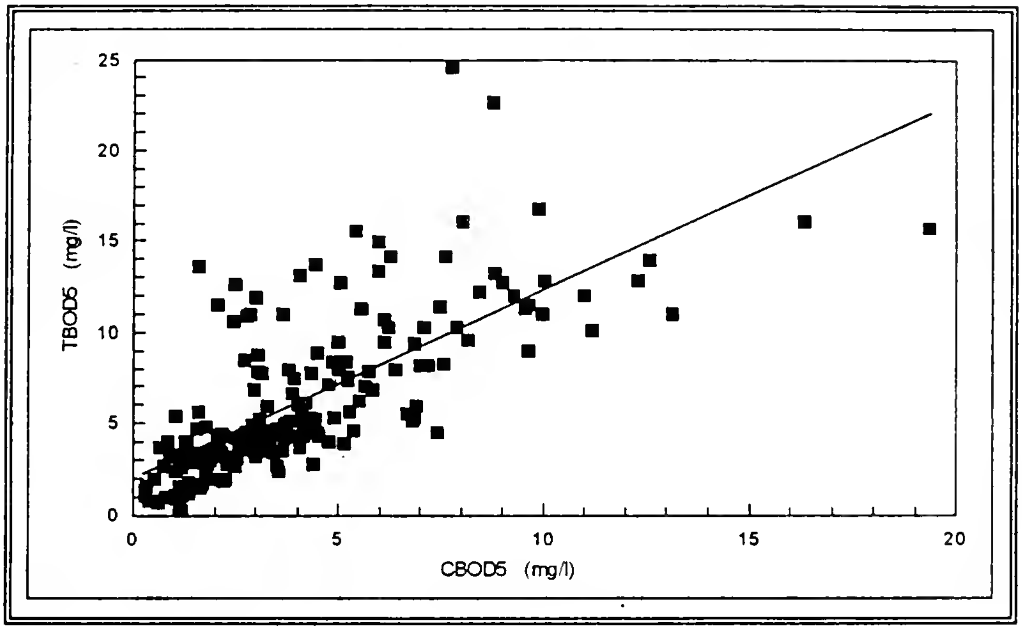
(c) **FALL**



(d) **WINTER**



(e) ALL YEAR



A similar regression analysis was carried out to investigate whether the inclusion to total ammonia nitrogen in the models significantly improved the correlation between $TBOD_5$ and $CBOD_5$ parameters. The results of this analysis is given in Table 5.4.

Table 5.4 Statistical Models for $TBOD_5$ vs ($CBOD_5$ and total NH_3-N Relationship)

(a) SPRING

Total NH_3-N range (mg/L)	$TBOD_5$ vs ($CBOD_5$ and NH_3)		
	Model	R^2	n
< 2	Same as $TBOD_5$ vs $CBOD_5$ model*		
2 - 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
> 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
All data	Same as $TBOD_5$ vs $CBOD_5$ model*		

(b) SUMMER

Total NH_3-N range (mg/L)	$TBOD_5$ vs $CBOD_5$ and NH_3		
	Model	R^2	n
< 2	Same as $TBOD_5$ vs $CBOD_5$ model*		
2 - 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
> 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
All data	Same as $TBOD_5$ vs $CBOD_5$ model*		

(c) FALL

Total NH_3-N range (mg/L)	$TBOD_5$ vs ($CBOD_5$ and NH_3)		
	Model	R^2	n
< 2	$TBOD_5 = 0.41 + 0.84\ CBOD_5 + 1.55\ NH_3$	0.60	40
2 - 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
> 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
All data	$TBOD_5 = 0.27 + 1.27\ CBOD_5 + 0.54\ NH_3$	0.51	52

(d) WINTER

Total NH_3-N range (mg/L)	$TBOD_5$ vs ($CBOD_5$ and NH_3)		
	Model	R^2	n
< 2	Same as $TBOD_5$ vs $CBOD_5$ model*		
2 - 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
> 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
All data	$TBOD_5 = 1.20 + 0.99\ CBOD_5 + 1.23\ NH_3$	0.62	49

(e) ALL YEAR

Total NH_3-N range (mg/L)	$TBOD_5$ vs ($CBOD_5$ and NH_3)		
	Model	R^2	n
< 2	$TBOD_5 = 0.15 + 0.87\ CBOD_5 + 1.50\ NH_3$	0.61	95
2 - 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
> 11	Same as $TBOD_5$ vs $CBOD_5$ model*		
All data	$TBOD_5 = 1.23 + 1.02\ CBOD_5 + 0.17\ NH_3$	0.58	191

(*In this case, the coefficients of ammonia were not significantly different from zero)

The resulting equations indicate that the influence of ammonia on the relationship is not very significant. This observation confirms the conclusion of various other researchers that NOD is limited by the amount of nitrifying bacteria rather than the ammonia concentration present in the sample. Also, the analysis involving other parameters (such as TKN, NO_2^--N, NO_3^--N and NO_x^--N) did not produce any significant or consistent improvement over the relationships involving only $TBOD_5$ and $CBOD_5$. As discussed earlier, these relationships will be of limited use since TKN, NO_2^--N, NO_3^--N and NO_x^--N are seldom measured in the same effluent samples tested for BOD_5.

Furthermore, Tables 5.3 (a)-(e) show that the correlations between $TBOD_5$ and $CBOD_5$ are, in general (except for the spring data), not found to be satisfactory. The R-squares above 0.67 are usually considered to give acceptable relationships. As expected, the correlation was the worst during summer since the influence of the nitrifying bacteria during this period would be the greatest as discussed earlier. This observation agrees with the U.S. EPA position that there would be little or no correlation between $TBOD_5$ and $CBOD_5$ during the warm weather conditions since the amount of nitrifying bacteria present in the effluent samples may be highly variable causing erratic NOD exerted in the 5-day BOD tests. The spring data gave the best correlation (R-squares = 0.80) although it was expected with the winter data. The grouping of the data with respect to the initial total ammonia nitrogen concentrations to approximate the influence of nitrifiers also did not produce any significant improvement in the relationship between $TBOD_5$ and $CBOD_5$ over the ungrouped data.

5.4 <u>Performance/Compliance Limits for Secondary Treatment Works</u>

Assuming the relationships under the "all data" category for the different seasons, Table 5.5 gives equivalent $CBOD_5$ values for $TBOD_5$ values of 30 and 25 mg/L, the limits that are widely used in the U.S. and Canada as the minimum treatment compliance requirements for secondary sewage treatment facilities.

Table 5.5 Equivalent Values of $TBOD_5$ and $CBOD_5$ under Different Seasons

$TBOD_5$ (mg/L)	$CBOD_5$ (mg/L)					
	US EPA	Spring	Summer	Fall	Winter	**All Year**
30	25	23	27	23	31	**27**
25	-	19	22	19	25	22

It should be noted that these mathematical relationships were derived by combining the entire data collected from all the 23 STPs selected for this study irrespective of whether the effluent was chlorinated or not. Therefore, the established relationships between $TBOD_5$ and $CBOD_5$ should be used with caution in trying to compare the two parameters for an individual facility.

As for the effluent limit setting for secondary sewage treatment facilities, two scenarios may be considered. Firstly, for annual performance limits, when data for the entire year are considered, the minimum treatment requirement of 25 mg/L of $TBOD_5$ becomes equivalent to 22 mg/L of $CBOD_5$. However, a difference of 3 mg/L in a BOD_5 result at these levels is not very significant, even if this is considered as a relaxation of effluent standard. In practical terms, the 3 mg/L difference cannot be taken advantage of since no biological treatment operation can be fine tuned to the extent to produce an effluent with a $CBOD_5$ of 3 mg/L higher. On the other hand, to meet monthly performance compliance, treatment works have to be designed based on winter conditions when biological treatment is at the lowest efficiency. Table 5.5 shows that the equivalent $CBOD_5$ value remains the same as the $TBOD_5$ value of 25 mg/L in winter. Therefore, based on the above discussion, an initial $CBOD_5$ concentration of 25 mg/L as the minimum secondary treatment non-compliance requirement appears to be reasonable. This limit may be tightened once a large enough $CBOD_5$ data base is established for the performance of the secondary treatment facilities.

5.5 Effects of Chlorination on $TBOD_5$/$CBOD_5$ Relationship

Although the majority of the plant effluents collected were unchlorinated, some chlorinated samples were also analyzed during the study to investigate the effects of chlorination on the relationship between $TBOD_5$ and $CBOD_5$. The statistical procedure of "analysis of covariance" with F-test at 0.05 level of significance was used and the results are presented in Table 5.6. Unfortunately, only two chlorinated samples were analyzed during summer sampling period due to a scheduling difficulty encountered at the analysis lab and therefore, these data are not considered in the following discussion. It is evident from the results that the correlation between $TBOD_5$ and $CBOD_5$ is consistently and significantly better with the chlorinated effluents(R-squares ranging between 0.78-0.82) than with unchlorinated samples (R-squares ranging between 0.19-0.81).

Table 5.6 Effects of Chlorination on the Relationship between $TBOD_5$ and $CBOD_5$

(a) CHLORINATED

Season	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
Spring	$TBOD_5 = 0.96 + 1.15\ CBOD_5$	0.81	22
(Summer)*	($TBOD_5 = 0.84 + 0.47\ CBOD_5$)	(1.00)	(2)
Fall	$TBOD_5 = 0.19 + 1.14\ CBOD_5$	0.78	17
Winter	$TBOD_5 = 0.92 + 0.95\ CBOD_5$	0.82	18
All Year	$TBOD_5 = 0.74 + 1.05\ CBOD_5$	0.81	59

(* Only 2 samples were analyzed during summer sampling period)

(b) UNCHLORINATED

Season	$TBOD_5$ vs $CBOD_5$		
	Model	R^2	n
Spring	$TBOD_5 = 0.12 + 1.44\ CBOD_5$	0.81	29
Summer	$TBOD_5 = 2.92 + 0.96\ CBOD_5$	0.19	38
Fall	$TBOD_5 = 2.10 + 1.39\ CBOD_5$	0.36	35
Winter	$TBOD_5 = 3.33 + 0.89\ CBOD_5$	0.56	32
All Year	$TBOD_5 = 2.44 + 1.07\ CBOD_5$	0.47	134

It may be speculated that the effect of chlorination on the nitrifying autotrophic bacteria (with slower growth rates) would be greater than on the fast growing heterotrophic bacteria responsible for the degradation of organic material. As a result, the amount of nitrifiers in the chlorinated effluents may be smaller than in unchlorinated effluents causing less interference. This hypothesis is in agreement with the observation that the corresponding NODs (= $TBOD_5$ - $CBOD_5$) in the chlorinated samples are less than those in the unchlorinated samples (Tables 5.7 and 5.8). Since chlorination is only a disinfection process (and not a sterilization process) it is quite possible that not all nitrifying organisms are killed. Consequently, $CBOD_5$ is generally smaller than $TBOD_5$. The greatest average difference between $TBOD_5$ and $CBOD_5$ occurred in the Spring; a 25 mg/L of $TBOD_5$ is found to be equivalent to 21 mg/L of $CBOD_5$. However, such a difference is not considered as significant in practical terms.

Table 5.7 Equivalent Values of $CBOD_5$ for 25 mg/L of $TBOD_5$ under Chlorination

Sample	Equivalent $CBOD_5$ (mg/L) for 25 mg/L of $TBOD_5$				
	Spring	Summer	Fall	Winter	All Year
Chlorinated	21	-	22	25	23
Unchlorinated	17	23	16	24	21

Table 5.8 Nitrogenous Oxygen Demand Exerted for 25 mg/L of $TBOD_5$ under Chlorination

Sample	NOD (mg/L) for 25 mg/L of $TBOD_5$				
	Spring	Summer	Fall	Winter	All Year
Chlorinated	4	-	3	0	2
Unchlorinated	8	2	9	1	4

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The important findings from this study are listed as follows:

- Both the literature, including the Standard Methods, and the U.S. EPA stated that the effluent $TBOD_5$ measurements may be erratic and/or misleading when nitrification or incipient nitrification occurs in a treatment facility. As such, $CBOD_5$ appeared to be the logical parameter for effluent limit setting for secondary STP effluents. Total ammonia-N or TKN should be monitored if the nitrogenous oxygen demand in the receiving water body is a concern based on water quality studies.

- The difference between $TBOD_5$ and $CBOD_5$ is primarily due to nitrification occurring in the BOD bottles during the test. The extent of this nitrogenous oxygen demand (NOD) exerted depends on the amount of nitrifiers present.

- No correlation between $TBOD_5$ and total ammonia nitrogen in the final effluent exists.

- The 2-chloro-6 (trichloro methyl) pyridine (TCMP) added to inhibit nitrification during the $CBOD_5$ testing, in accordance with the Standard Methods (APHA, 1989), did not appear to have affected the heterotrophic organisms responsible for the degradation of organic matter in secondary effluents during the 5-day period of the test.

- No definite relationship between $TBOD_5$ and $CBOD_5$ was found to exist when no differentiation was made between chlorinated and unchlorinated samples. However, a fairly good relationship was found to exist between $TBOD_5$ and $CBOD_5$ among the chlorinated samples. The equivalent $CBOD_5$ value for 25 mg/L of $TBOD_5$ was found to range between 21-23 mg/L, depending on whether the effluent was chlorinated or not. When no differentiation was made, on the average, 25 mg/L of $TBOD_5$ and 22 mg/L of $CBOD_5$ were found to be equivalent.

6.2 Recommendations

With respect to the issue of $TBOD_5$ versus $CBOD_5$ as a parameter for effluent limit setting of secondary sewage treatment facilities, the following recommendations are made:

- $CBOD_5$ should be used for the measurement of secondary sewage treatment works performance and as an indicator of their effluent quality.

- In cases where the nitrogenous oxygen demand in the receiving water body is of concern, the effluent quality from the treatment facilities should be monitored using either TKN or total ammonia nitrogen. (Unionized ammonia nitrogen concentrations should be limited if ammonia toxicity is of concern in the receiving water body.

- An extensive $CBOD_5$ data base should be established in order to set a defensible $CBOD_5$ limit as a minimum secondary treatment requirement. In the interim, a $CBOD_5$ limit of 25 mg/L is reasonable.

7. REFERENCES

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8. APPENDIX

The results of the laboratory analysis for different seasons are presented in this section.

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0 2	0 05	0 05	0 005	0 05
T	1 0	0 25	0 25	0.025	0 25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

<u>**SPRING - May 1992**</u> <u>**NE Region**</u>

Location	Chlorinated?	Dilution	TCMP?	TBOD5	CBOD5	NH3+NH4		TKN		NO2		NO2+NO3	
	(Y/N)	mL to 100	(Y/N)	(mg/L)	(mg/L)	DAY 0	DAY 5	DAY 0	DAY 5	DAY 0	DAY 5	DAY 0	DAY 5
AZILDA	N	25	N	4.88		<T	<T	0.55	0 50	0.03	0.10	4.55	4.60
	N	50	N	2.78		<T	<T	0 85	0.75	0 06	0 15	9.30	9.40
	N	25	Y		4 16	<T	<T	0 60	0 65	0 04	0 04	4 55	4.80
	N	50	Y		2.28	<T	<T	0 90	0 80	0.07	0.06	9.05	9 30
FALCON-BRIDGE	N	25	N	2 68		<T	<T	0 25	0 30	<W	<T	<W.	<W
	N	50	N	1.70		<T	<T	0.35	0.30	<W	<T	<T	<T
	N	25	Y		2 48	<T	<T	0 30	0 30	<W	<W	<T	<W
	N	50	Y		1 48	<T	<T	0 40	0 30	<W	<T	<T	<W
LATCH-FORD	N	25	N	4 20		<T	<W	0.60	0 45	<W	<T	N/A	3 15
	N	50	N	2.78		N/A	<W	0.90	0.70	0.07	<T	N/A	6.30
	N	25	Y		2 48	<T	<T	0 60	0 50	<T	<T	2.95	2.95
	N	50	Y		1 82	<T	<T	0 95	0 85	<T	<T	6 00	6 05

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.05	0.05	0.005	0.05
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

SPRING - May 1992 **CE Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
ACTON	Y	50	N	1.18		<T	<T	0.65	0.55	0.04	0.05	8.40	8.70
	Y	100	N	1.10		0.30	0.35	0.65	0.90	0.08	0.09	18.20	18.10
	Y	50	Y		1.36	<T	<T	0.60	0.85	0.04	0.04	8.45	8.35
	Y	100	Y		1.19	0.30	0.35	0.95	1.00	0.08	0.11	18.00	18.00
BARRIE	Y	50	N	4.24		0.55	0.60	1.20	1.25	0.03	0.11	4.75	5.15
	Y	100	N	4.42		1.00	0.95	2.20	2.90	0.07	0.40	10.10	10.70
	Y	50	Y		3.68	0.50	0.60	1.40	1.30	0.03	0.08	4.70	5.05
	Y	100	Y		3.37	0.95	1.15	2.30	2.25	0.08	0.12	9.85	10.50
COBOURG 1	N	50	N	3.68		<T	<T	0.65	0.65	<T	<T	<T	<T
	N	100	N	4.18		<T	<T	1.10	1.15	<T	<T	<T	<T
	N	50	Y		4.08	<T	<T	0.65	0.65	<T	<T	<T	<T
	N	100	Y		4.04	<T	0.25	1.10	1.15	<T	<T	<T	<T
COBOURG 2	N	50	N	4.52		4.35	4.45	7.05	7.00	0.07	0.17	1.05	1.40
	N	100	N	4.02		9.05	9.25	14.10	14.10	0.15	0.44	2.40	3.20
	N	50	Y		2.78	4.30	4.45	7.15	7.05	0.07	0.09	1.15	1.25
	N	100	Y		3.30	9.00	9.35	14.40	14.30	0.15	0.20	2.55	2.75
DUFFIN CREEK	N	50	N	14.18		6.60	5.30	7.35	5.95	2.03	2.45	5.60	7.15
(Cl2 compound	N	100	N	N/A		13.50	12.40	14.80	13.50	4.30	4.90	11.40	12.90
detected)	N	50	Y		6.26	6.75	6.70	7.55	7.45	2.08	0.91	5.55	5.85
	N	100	Y		5.97	13.30	13.40	14.10	14.90	4.20	2.10	11.10	11.60
LAKEVIEW	Y	50	N	10.68		9.00	8.10	11.20	9.95	0.13	1.06	1.15	1.90
	Y	100	N	7.83		18.30	17.90	22.50	21.70	0.27	1.20	2.30	3.05
	Y	50	Y		6.10	9.10	8.70	11.50	10.60	0.13	0.25	1.15	1.15
	Y	100	Y		5.73	18.20	18.40	22.60	22.20	0.28	0.49	2.25	2.40
MAIN	N	50	N	8.84		10.10	10.10	11.60	11.40	1.02	0.97	2.15	3.15
	N	100	N	8.00		21.20	20.60	24.00	22.70	2.13	1.42	4.60	5.85
	N	50	Y		4.50	10.20	10.40	11.80	11.70	1.03	0.41	2.15	2.30
	N	100	Y		5.00	21.10	21.30	23.90	23.60	2.08	0.89	4.50	5.15
NORWOOD	N	25	N	5.36		<T	<T	0.55	0.50	<T	0.07	5.45	5.30
	N	50	N	4.14		<T	<T	0.70	0.75	0.03	0.09	10.10	9.80
	N	25	Y		4.28	<T	<T	0.50	0.56	<T	<T	4.75	4.80
	N	50	Y		2.78	<T	0.30	0.65	0.65	<T	0.03	9.75	9.50
OAKVILLE S/E	Y	25	N	7.76		1.60	1.30	2.10	1.80	0.11	0.24	3.15	3.40
	Y	50	N	4.76		2.60	2.25	3.30	2.75	0.20	0.47	5.85	6.40
	Y	25	Y		4.32	1.50	1.50	2.10	2.00	0.12	0.12	3.35	3.30
	Y	50	Y		3.52	2.60	2.25	3.35	3.45	0.20	0.24	5.95	6.40
OAKVILLE S/W	Y	25	N	12.76		3.45	3.00	4.15	3.65	0.08	0.36	<T	0.70
	Y	50	N	11.40		6.45	5.40	7.70	6.45	0.15	0.50	0.25	1.35
	Y	25	Y		9.00	3.70	3.30	4.45	3.95	0.08	0.07	<T	<T
	Y	50	Y		7.46	6.75	6.70	8.05	7.85	0.15	0.07	0.25	0.30
PORT-HOPE	N	50	N	3.96		<T	<T	0.75	0.60	0.11	0.10	4.60	5.10
	N	100	N	3.13		<T	<T	1.00	0.90	0.22	0.18	10.10	10.50
	N	50	Y		3.14	<T	<T	0.75	0.65	0.11	0.08	4.85	5.05
	N	100	Y		2.51	<T	<T	1.25	1.05	0.21	0.10	10.00	10.40
SKY WAY	Y	25	N	13.92		3.20	2.70	3.85	3.10	0.06	0.25	0.70	1.35
	Y	50	N	10.96		5.95	4.85	6.80	5.40	0.11	0.44	1.30	2.65
	Y	25	Y		12.56	3.25	3.20	3.75	3.65	0.06	0.06	0.70	0.85
	Y	50	Y		3.66	5.95	5.75	6.65	6.30	0.11	0.14	1.30	1.75
STOUFFVILLE	N	25	N	4.12		0.25	0.25	0.56	0.50	0.04	0.09	2.35	2.50
	N	50	N	2.50		0.35	0.30	0.75	0.65	0.07	0.17	4.30	4.55
	N	25	Y		6.96	0.25	0.30	0.60	0.90	0.04	0.04	2.35	2.55
	N	50	Y		7.94	0.35	0.40	0.60	0.75	0.06	0.05	4.40	4.00
SUTTON	N	25	N	16.72		1.10	1.45	2.20	2.15	0.03	0.04	<T	<T
	N	50	N	16.06		2.05	2.65	4.05	3.85	0.05	0.07	<T	<T
	N	25	Y		9.88	1.05	1.45	2.05	2.20	0.03	0.03	<T	<T
	N	50	Y		8.00	2.00	2.70	4.00	4.60	0.05	0.05	<T	<T

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.05	0.05	0.005	0.05
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

SPRING - May 1992 **WC Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
BRANTFORD	N	25	N	11.28		1.05	0.24	1.65	0.95	0.04	0.38	1.55	2.45
	N	50	N	12.84		1.90	0.35	3.15	1.65	0.07	0.88	2.90	4.85
	N	25	Y		9.52	1.05	0.65	1.60	1.30	0.04	0.18	1.60	2.00
	N	50	Y		12.28	1.90	0.80	3.20	2.00	0.07	0.52	2.95	4.25
	Y	25	N	8.92		1.10	0.35	1.85	1.05	0.04	0.83	1.60	2.30
	Y	50	N	11.04		1.90	0.50	3.15	1.70	0.07	1.65	2.95	4.45
	Y	25	Y		9.64	1.10	0.70	1.85	1.40	0.04	0.43	1.65	1.85
	Y	50	Y		9.94	1.95	1.10	3.25	2.35	0.07	1.02	3.00	3.80
CAYUGA	N	25	N	1.04		<T	<T	0.50	0.40	0.02	0.09	5.50	5.15
	N	50	N	0.78		<T	<T	0.65	0.60	0.04	0.10	10.50	10.70
	N	25	Y		0.28	<T	<T	0.45	0.45	0.02	0.04	5.10	5.40
	N	50	Y		0.48	<T	<T	0.70	0.70	0.04	0.08	10.70	11.00
	Y	25	N	1.28		<T	<T	0.45	0.45	N/A	<T	5.50	5.40
	Y	50	N	0.68		<T	<T	0.65	0.60	N/A	<T	10.60	10.50
	Y	25	Y		1.32	<T	<T	0.50	0.50	N/A	<T	5.35	5.30
	Y	50	Y		0.60	<T	<T	0.65	0.65	N/A	<T	10.40	10.40
ELORA	N	25	N	1.60		<T	<T	0.40	0.35	0.02	0.04	2.65	2.60
	N	50	N	1.08		<T	<T	0.60	0.45	0.03	0.08	5.05	5.35
	N	25	Y		1.20	<T	<T	0.45	0.40	0.02	0.03	2.85	2.85
	N	50	Y		1.20	<T	<T	0.65	0.55	0.03	0.04	5.25	5.05
	Y	25	N	1.44		<T	<T	0.40	0.40	<T	<T	2.45	2.35
	Y	50	N	1.60		<T	<T	0.65	0.65	<T	<T	4.35	4.56
	Y	25	Y		1.64	<T	<T	0.40	0.40	N/A	<T	2.30	2.35
	Y	50	Y		0.32	<T	<T	0.60	0.60	<T	<T	4.55	4.80
HESPELER	N	25	N	12.44		4.00	3.35	4.85	4.10	0.54	0.91	0.95	1.70
	N	50	N	13.08		8.15	7.20	9.65	8.25	1.10	1.16	1.85	2.95
	N	25	Y		6.00	4.10	4.15	4.95	4.80	0.55	0.40	0.95	1.05
	N	50	Y		8.10	8.05	8.10	9.60	9.10	1.08	0.80	1.75	2.30
	Y	25	N	9.72		3.60	3.35	4.50	4.05	0.62	0.82	1.05	1.10
	Y	50	N	9.80		8.85	8.65	8.30	7.80	1.17	1.54	1.90	2.10
	Y	25	Y		6.44	3.50	3.70	4.40	4.45	0.60	0.66	1.00	0.95
	Y	50	Y		7.94	6.70	6.95	8.35	8.15	1.16	1.29	1.65	1.90
SHELBURNE	N	25	N	9.48		3.10	2.45	3.50	2.60	0.01	0.40	0.10	0.56
	N	50	N	10.30		5.15	4.90	6.40	5.65	0.02	0.59	0.10	1.25
	N	25	Y		5.00	2.95	3.00	3.40	3.40	0.01	0.10	0.10	<T
	N	50	Y		6.20	5.85	5.45	6.70	6.20	0.02	0.18	0.10	0.45
	Y	25	N	3.20		2.85	2.85	3.20	3.15	0.06	0.19	0.10	<T
	Y	50	N	3.80		5.65	5.40	6.40	6.00	0.13	0.72	0.25	0.70
	Y	25	Y		0.92	3.00	3.00	3.40	3.40	0.07	0.11	0.20	<T
	Y	50	Y		1.32	5.60	5.75	6.30	6.25	0.13	0.27	0.30	0.30
ST.JACOBS	N	25	N	6.08		<T	<T	0.65	0.56	0.09	0.16	4.75	4.95
	N	50	N	4.68		<T	<T	0.95	0.70	0.17	0.27	9.20	9.10
	N	25	Y		4.00	<T	<T	0.65	0.65	0.09	0.10	4.70	4.90
	N	50	Y		3.68	<T	<T	1.00	0.85	0.17	0.19	8.95	9.30
	Y	25	N	0.28		<T	<T	0.60	0.56	0.02	<T	4.70	4.65
	Y	50	N	0.68		0.25	0.25	0.90	0.95	0.03	0.03	8.95	8.35
	Y	25	Y		1.20	<T	<T	0.65	0.55	0.02	<T	4.65	4.30
	Y	50	Y		1.04	0.25	0.30	0.90	0.90	0.03	0.03	8.75	8.70

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0 2	0 05	0 05	0 005	0 05
T	1 0	0 25	0 25	0 025	0 25
?	Unreliable result, please ignore				
N/A	Not Available				
!CR	Could not repeat analysis to confirm result				
RO	Run-out				

SUMMER - August 1992 **NE Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
AZILDA	N	25	N	5.28		0.30	<T	0.75	0.65	<T	0.14	3.95	4.30
	N	50	N	3.54		<T	<T	0.90	0.70	0 03	0 14	7.80	8.45
	N	25	Y		6 84	0 30	0 35	0 75	0 80	<T	<T	4 10	4 45
	N	50	Y		3 12	<T	0.30	0 90	0 85	0 03	<T	7 80	8 30
FALCON-BRIDGE	NOT RECEIVED												
LATCH-FORD	NOT RECEIVED												

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0 2	0 05	0 05	0 005	0 05
T	1 0	0 25	0 25	0 025	0 25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

SUMMER - August 1992 **CE Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
ACTON		NOT RECEIVED											
BARRIE	N	25	N	8 40		0.75	0.80	1.30	1.25	0.03	0.08	3.40	3.45
	N	50	N	5.52		1 00	1.05	1.90	1.85	0.05	0.15	6.95	7.10
	N	25	Y		4 84	0.75	0 80	1.35	1.35	0 03	0.04	3 35	3 35
	N	50	Y		4 08	1 00	1 10	1.85	1.90	0 05	0.08	6.90	6 90
COBOURG 1	N	25	N	3 20		4.05	4.05	4 45	4 35	0.04	0.08	<T	<T
	N	50	N	1.66		7.65	7.65	8.30	8.10	0.07	0 11	<T	<T
	N	25	Y		2.20	4 00	3 90	4 45	4.30	0 04	0.07	<T	<T
	N	50	Y		1 70	7 65	7 40	8 50	8.20	0 07	0 04	<T	<T
COBOURG 2	N	25	N	4 60		4 20	4.10	6 00	5.90	0.04	0.08	<T	<T
	N	50	N	4 30		8 00	7.85	11.70	11.30	0.08	0.13	<T	<T
	N	25	Y		5 36	4 25	4 20	6 20	6 10	0 04	0 05	<T	<T
	N	50	Y		4 14	8 00	7 90	11 70	11 50	0 08	0 09	<T	<T
DUFFIN CREEK	N	25	N	13 12		2.55	1.95	3 00	2.35	0.12	0.23	1.35	2.05
	N	50	N	12 58		4.95	3 60	5 85	4 05	0.25	0.43	2.85	4.00
	N	25	Y		4.04	2 55	2.70	3 10	3 15	0 12	0 05	1.35	1.35
	N	50	Y		2.48	4 70	4 80	5 40	5 30	0.23	0 06	2.70	2.65
LAKEVIEW	N	25	N	4.78		1 20	1.15	2.05	1.95	0.03	0.18	2.56	2.70
	N	50	N	4 66		1.90	1.70	3 35	3 05	0.06	0.39	5.25	5.55
	N	25	Y		2 96	1 25	1 25	2 10	2.05	0.03	0 04	2.55	2.55
	N	50	Y		2 92	1 85	1 95	3 25	3 35	0 06	0.09	5.20	5.20
MAIN	N	25	N	15.56		4 25	3.75	4.75	4.20	0 65	0.68	1.65	2.40
	N	50	N	13 74		7.90	7.20	6.70	7 85	1.27	1.23	3.15	4 75
	N	25	Y		5 40	4 20	4 55	4 75	4 80	0 65	0.27	1.55	1.70
	N	50	Y		4 42	8 15	8 55	8 95	8 95	1 33	0 40	3 25	3.50
NORWOOD	Y	25	N	1.88		0 30	0.35	0.70	0.70	<T	<T	2.60	2.80
	Y	50	N	1.38		0 30	0.35	0.80	0.85	0.03	0.04	5.25	5.35
	Y	25	Y		2.20	0 35	0 35	0 70	0 75	<T	<T	2.45	2.60
	Y	50	Y		1 14	0 25	0 30	0 85	0 90	0 03	0 04	5.10	5 35
OAKVILLE S/E	N	25	N	3.64		3 70	3.40	4.00	3.65	<T	0 06	<W	<T
	N	50	N	3.18		6 65	6.65	7.25	7.15	<T	0 13	<W	<T
	N	25	Y		2.64	3 50	3 55	3 65	3 85	<T	<T	<W	<T
	N	50	Y		2.32	6 65	6 60	7 25	7 15	<T	0 03	<T	<T
OAKVILLE S/W	N	25	N	3 92		1.65	1.65	2.10	2 00	0.21	<T	0.45	0.50
	N	50	N	4.00		2 90	2.95	3 60	3 65	0 41	<T	0.95	1.15
	N	25	Y		2 88	1 70	1 60	2.15	2 05	0 21	<T	0 45	0 45
	N	50	Y		3 18	2 85	2 85	3 65	3 55	0 40	<T	0 90	0 95
PORT HOPE	N	25	N	4 88		0.45	0 30	0 85	0 70	<T	0.08	3 90	4 05
	N	50	N	3 34		0 35	<T	0.65	0.70	<T	0 09	7.95	8.20
	N	25	Y		2 88	0 50	0 45	0 85	0 90	<T	<T	3 85	3 85
	N	50	Y		1 44	0 35	0 35	0 90	0 90	<T	<T	7 90	7.95
SKY WAY	N	25	N	10 84		3 30	3.05	3 60	3 35	0 10	0.22	0.40	1 05
	N	50	N	10 64		6 35	5 40	6 90	5 75	0.20	0.34	0.85	2 10
	N	25	Y		2 76	3 35	3 50	3 75	3 85	0 10	0 06	0 40	0 55
	N	50	Y		2 44	6 30	6 25	7 05	6 80	0 20	0 06	0.85	1 00
STOUFFVILLE	N	25	N	3 28		0 50	0.40	0.75	0 65	0 06	0.14	0.09	1.05
	N	50	N	2 68		0.60	0 35	1 05	0 80	0 17	0 25	2.00	2 05
	N	25	Y		1 28	0 50	0 50	0 80	0 80	0 09	0 08	0 90	1 00
	N	50	Y		0 76	0 60	0 60	1 05	1 00	0 16	0 11	1.85	1 95
SUTTON	N	25	N	3.08		3 40	3 65	3 90	4 15	<T	0 06	<W	<T
	N	50	N	3 42		6 85	6 45	7 90	7 40	0 03	0.11	<W	<T
	N	25	Y		1 88	3 50	3 50	4 10	4 05	<T	<T	<W	<W
	N	50	Y		2 14	6 45	8 75	7 50	7 85	0 03	0 03	<W	<T

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.05	0.05	0.005	0.05
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

SUMMER - August 1992 **WC Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
BRANTFORD	N	25	N	14.96		0.35	<T	1.15	0.85	0.10	0.13	1.65	1.90
	N	50	N	8.26		0.25	<T	1.35	1.25	0.21	0.18	3.25	3.65
	N	25	Y		5.96	0.35	0.35	1.00	1.00	0.11	0.07	1.65	1.70
	N	50	Y		7.56	0.25	0.35	1.45	1.56	0.20	0.11	3.20	3.35
CAYUGA	N	25	N	4.76		0.30	<T	0.65	0.55	<T	0.08	4.20	4.45
	N	50	N	2.38		<T	<T	0.70	0.60	<T	0.11	8.70	8.85
	N	25	Y		1.56	0.30	0.30	0.65	0.70	<T	<T	4.20	4.25
	N	50	Y		1.06	<T	0.25	0.75	0.80	<T	<T	8.70	8.70
ELORA	N	25	N	4.48		0.35	0.25	0.60	0.50	<T	0.09	2.25	2.35
	N	50	N	2.38		0.25	<T	0.60	0.45	0.04	0.15	4.55	4.70
	N	25	Y		7.40	0.30	0.30	0.65	0.65	<T	<T	2.35	2.25
	N	50	Y		3.56	0.25	0.30	0.70	0.70	0.04	0.03	4.60	4.35
HESPELER	N	25	N	8.40		0.35	0.25	0.85	0.65	0.04	0.16	3.85	4.05
	N	50	N	6.10		0.25	<T	0.95	0.70	0.07	0.20	7.20	7.25
	N	25	Y		5.16	0.30	0.35	1.05	0.85	0.04	0.04	3.70	3.60
	N	50	Y		4.20	0.25	0.30	1.20	1.00	0.07	0.07	7.55	7.30
SHELBURNE	N	25	N	8.48		0.40	<T	0.70	0.45	<T	0.09	0.90	1.20
	N	50	N	5.66		0.45	<T	0.95	0.55	<T	0.07	1.75	2.20
	N	25	Y		2.72	0.40	0.45	0.80	0.80	<T	<T	0.65	0.95
	N	50	Y		1.62	0.45	0.50	1.05	1.00	<T	<T	1.75	1.70
ST.JACOBS	N	25	N	4.16		0.30	0.30	0.80	0.55	<T	0.06	3.55	3.96
	N	50	N	3.36		0.25	<T	0.65	0.55	0.03	0.11	7.10	7.30
	N	25	Y		2.56	0.30	0.35	0.65	0.65	<T	<T	3.55	3.50
	N	50	Y		1.38	0.25	0.30	0.70	0.70	0.03	<T	7.40	7.15

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0 2	0 05	0 05	0 005	0 05
T	1 0	0.25	0 25	0 025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

<u>FALL - November 1992</u> <u>NE Region</u>

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
AZILDA	N	25	N	4.00		0 35	<T	0.75	0.50	<T	0.15	3.00	3.30
	N	50	N	2.88		0 25	<T	0.85	0.50	<T	0.14	6 05	6.10
	N	25	Y		1 28	0 35	0 40	0 80	0 80	<T	<T	3 00	2.95
	N	50	Y		1 52	0.25	0 30	0 90	1 05	<T	<T	5 85	5 80
FALCON-BRIDGE	N	25	N	2.84		0 40	0 40	0 45	0.45	<T	<T	<T	<T
	N	50	N	2.30		0 30	0 30	0 45	0.40	<T	<T	<T	<T
	N	25	Y		1.12	0 40	0 40	0 55	0 55	<T	<T	<T	<T
	N	50	Y		1.78	0 30	0 35	0 55	0 50	<T	<T	<T	<T
LATCH-FORD	N	25	N	8 72		0.35	<T	0 85	0 40	<W	0.05	2.10	2.55
	N	50	N	4 84		0 25	<W	1.15	0.80	<T	<T	4.45	4.85
	N	25	Y		3 04	0 30	0 40	0 95	1 05	<W	<W	2 20	2 30
	N	50	Y		1 78	0 25	0 30	1 20	1.35	<W	<W	4.50	4 45
LATCH-FORD	Y	25	N	5 82		0.35	<T	0.90	0 80	<W	0.12	2 10	2.45
	Y	50	N	4 32		0.25	<T	1.15	0.80	<W	0.08	4.20	4.60
	Y	25	Y		3 28	0 35	0 35	0.90	0 90	<W	<W	2.05	2.10
	Y	50	Y		2 20	0 25	0 35	1.25	1.25	<T	<W	4 40	4 30

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.05	0.05	0.005	0.05
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

FALL - November 1992 **CE Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
ACTON		NOT RECEIVED											
BARRIE	N	25	N	4.52		1.05	1.10	1.45	1.40	<T	0.04	2.85	2.90
	N	50	N	1.62		1.60	1.65	2.10	2.15	0.03	0.05	5.30	5.60
	N	25	Y		2.76	1.05	1.10	1.45	1.50	<T	<T	2.65	2.90
	N	50	Y		1.14	1.60	1.65	2.30	2.15	0.03	0.04	5.55	5.45
COBOURG 1	Y	25	N	4.04		0.40	0.40	0.60	0.80	0.06	0.07	0.55	0.60
	Y	50	N	3.48		0.35	0.30	0.75	0.70	0.10	0.13	1.10	1.15
	Y	25	Y		4.76	0.40	0.35	0.70	0.70	0.05	0.06	0.55	0.60
	Y	50	Y		3.20	0.35	0.30	0.80	0.90	0.10	0.10	1.10	1.15
COBOURG 2	Y	25	N	5.84		1.35	1.35	2.10	2.00	0.09	0.09	0.70	0.70
	Y	50	N	4.74		2.25	2.30	3.75	3.65	0.18	0.18	1.45	1.45
	Y	25	Y		5.28	1.40	1.40	2.30	2.15	0.09	0.09	0.70	0.70
	Y	50	Y		4.20	2.30	2.40	3.90	3.80	0.17	0.17	1.45	1.50
DUFFIN CREEK	N	25	N	7.72		0.35	<T	0.80	0.45	0.08	0.21	6.95	7.50
	N	50	N	5.34		0.25	<T	0.90	0.70	0.17	0.21	14.20	14.40
	N	25	Y		3.12	0.30	0.35	0.85	0.85	0.08	0.05	6.95	6.95
	N	50	Y		4.90	0.25	0.30	1.10	0.90	0.16	0.08	13.70	14.60
LAKEVIEW	N	25	N	ICR		1.55	1.30	2.10	1.85	0.20	0.41	1.70	1.85
	N	50	N	9.82		2.65	2.20	3.50	3.00	0.38	0.86	3.25	3.75
	N	25	Y		9.06	1.55	1.55	2.15	2.15	0.19	0.19	1.60	1.70
	N	50	Y		ICR	2.55	2.75	3.55	3.80	0.37	0.40	3.15	3.40
MAIN	N	25	N	11.92		3.15	2.60	3.80	3.05	0.46	0.61	3.70	4.10
	N	50	N	11.00		5.70	4.80	6.45	5.55	0.88	1.24	7.25	8.65
	N	25	Y		3.00	2.95	3.15	3.65	3.75	0.43	0.26	3.45	3.70
	N	50	Y		2.86	5.60	6.10	6.70	7.00	0.87	0.43	7.10	7.85
NORWOOD	N	25	N	4.44		0.35	<T	0.75	0.40	0.15	0.27	3.65	3.85
	N	50	N	2.64		0.25	<T	0.70	0.45	0.29	0.43	7.05	7.70
	N	25	Y		2.16	0.30	0.35	0.85	0.60	0.15	0.13	3.60	3.80
	N	50	Y		1.16	0.25	0.30	0.75	0.70	0.30	0.23	7.25	7.80
PORT HOPE	N	25	N	9.60		0.50	<T	0.65	0.40	0.12	0.11	2.70	3.40
	N	50	N	7.00		0.50	<T	1.05	0.45	0.23	0.11	5.50	6.10
	N	25	Y		8.16	0.50	0.40	0.90	0.80	0.11	0.02	2.55	2.75
	N	50	Y		5.66	0.50	0.45	1.15	1.05	0.23	0.02	5.50	5.70
SKY WAY	N	25	N	11.52		1.40	0.60	1.70	0.80	0.06	0.30	1.15	2.00
	N	50	N	13.64		2.35	0.70	2.75	1.15	0.16	0.62	2.25	4.10
	N	25	Y		2.04	1.45	1.45	1.65	1.75	0.09	<T	1.20	1.15
	N	50	Y		1.60	2.40	2.45	2.90	2.90	0.16	0.03	2.30	2.35
OAKVILLE S/E		NOT RECEIVED											
OAKVILLE S/W	N	25	N	24.56		1.85	0.55	2.35	0.95	0.09	0.23	0.45	1.75
	N	50	N	ICR		3.25	2.15	4.15	2.60	0.18	0.60	0.85	2.35
	N	25	Y		7.72	1.75	1.85	2.30	2.20	0.09	<T	0.40	0.45
	N	50	Y		7.90	3.15	3.45	4.15	4.10	0.18	<T	0.85	1.10
STOUFFVILLE	N	25	N	5.40		0.40	<T	0.85	0.35	0.03	0.16	2.20	2.20
	N	50	N	3.70		0.35	<T	0.75	0.40	0.05	0.17	4.30	4.65
	N	25	Y		1.04	0.40	0.40	0.80	0.85	<T	<T	2.00	2.10
	N	50	Y		0.66	0.35	0.35	0.90	0.90	0.05	<T	4.10	4.25
SUTTON	N	25	N	2.00		2.95	3.00	3.20	3.15	0.03	0.05	0.65	0.85
	N	50	N	1.34		5.45	5.50	5.90	5.70	0.07	0.10	1.30	1.35
	N	25	Y		0.52	2.90	3.05	3.15	3.35	0.03	0.04	0.65	0.85
	N	50	Y		0.28	5.45	5.50	5.90	6.05	0.07	0.06	1.30	1.30

Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.05	0.05	0.005	0.05
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

FALL - November 1992 WC Region

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
BRANTFORD	N	25	N	9.52		0.45	<T	1.00	0.60	0.09	0.28	1.55	1.85
	N	50	N	7.38		0.45	<T	1.45	0.95	0.19	0.35	3.20	3.65
	N	25	Y		6.08	0.45	0.40	0.95	0.85	0.09	0.11	1.50	1.75
	N	50	Y		5.24	0.45	0.35	1.50	1.15	0.18	0.19	3.05	3.15
	Y	25	N	9.40		0.45	<T	1.00	0.60	0.09	0.25	1.40	1.85
	Y	50	N	3.90		0.50	<T	1.40	0.85	0.19	0.38	3.00	3.60
	Y	25	Y		6.84	0.45	0.45	1.00	0.90	0.09	0.07	1.40	1.40
	Y	50	Y		5.14	0.45	0.55	1.45	1.35	0.19	0.14	3.00	3.20
CAYUGA	N	25	N	4.96		0.30	<T	0.60	0.30	<W	0.16	1.60	1.85
	N	50	N	3.22		<T	<W	0.60	0.35	<T	0.10	3.10	3.40
	N	25	Y		3.68	0.30	0.30	0.55	0.55	<W	<T	1.60	1.65
	N	50	Y		1.54	<T	<T	0.75	0.60	<T	<T	3.10	3.25
	Y	25	N	1.96		0.30	0.30	0.55	0.55	<W	0.04	1.50	1.65
	Y	50	N	1.16		<T	<T	0.60	0.50	<W	0.04	3.20	3.20
	Y	25	Y		1.96	0.30	0.30	0.55	0.50	<W	<T	1.60	1.60
	Y	50	Y		1.24	<T	0.25	0.65	0.60	<W	<T	3.15	3.05
ELORA	N	25	N	3.56		0.30	<T	0.55	0.35	0.04	0.16	2.05	2.25
	N	50	N	0.98		0.25	<T	0.60	0.35	0.06	0.22	4.10	4.40
	N	25	Y		2.00	0.35	0.35	0.60	0.50	0.04	0.04	2.05	1.95
	N	50	Y		0.80	0.25	0.25	0.65	0.60	0.08	0.07	4.15	4.30
	Y	25	N	1.80		0.35	0.35	0.56	0.50	<T	0.03	2.10	2.35
	Y	50	N	1.06		0.25	0.25	0.60	0.55	<T	0.04	4.30	4.30
	Y	25	Y		1.36	0.35	0.35	0.60	0.55	<T	<T	2.05	2.35
	Y	50	Y		1.04	0.25	0.25	0.65	0.60	<T	0.03	4.30	4.45
HESPELER	N	25	N	4.56		0.30	0.25	0.75	0.60	0.01	0.08	3.00	3.15
	N	50	N	2.82		<T	<T	1.00	0.75	0.02	0.08	6.25	6.25
	N	25	Y		4.48	0.30	0.30	0.75	0.75	<T	0.03	2.75	3.30
	N	50	Y		4.36	<T	<T	0.85	0.90	<T	0.08	6.05	6.30
	Y	25	N	7.16		0.30	0.25	0.70	0.60	<T	0.08	2.90	2.95
	Y	50	N	4.32		<T	<T	0.90	0.70	<T	0.09	5.80	5.95
	Y	25	Y		4.76	0.30	0.30	0.75	0.65	<T	0.03	2.80	2.85
	Y	50	Y		3.96	<T	<T	0.95	0.90	<T	0.08	5.65	5.80
SHELBURNE	N	25	N	6.80		0.36	<T	0.70	0.40	<T	0.04	3.50	4.40
	N	50	N	4.00		0.30	<T	0.90	0.60	<T	0.04	8.65	7.55
	N	25	Y		2.96	0.35	0.35	0.80	0.70	<T	<W	3.50	3.40
	N	50	Y		2.10	0.30	0.35	0.95	0.80	<T	<W	7.30	7.00
	Y	25	N	0.76		0.35	0.35	0.60	0.50	<T	0.03	3.20	3.25
	Y	50	N	RO		0.30	0.30	0.65	0.55	<T	0.06	6.50	6.55
	Y	25	Y		0.40	0.35	0.40	0.60	0.55	<T	<T	3.25	3.25
	Y	50	Y		0.40	0.30	0.30	0.65	0.65	<T	<T	6.55	6.65
ST.JACOBS	N	25	N	5.16		0.30	<T	0.60	0.35	0.04	0.14	2.80	3.05
	N	50	N	3.30		<T	<T	0.65	0.40	0.09	0.13	5.80	6.15
	N	25	Y		3.84	0.30	0.30	0.60	0.55	0.04	0.03	2.90	3.15
	N	50	Y		1.76	<T	<T	0.70	0.60	0.09	0.05	6.05	6.00
	Y	25	N	3.52		0.30	0.30	0.60	0.55	<W	<T	2.75	2.80
	Y	50	N	1.98		<T	0.25	0.60	0.60	<W	0.04	5.45	5.70
	Y	25	Y		2.98	0.30	0.30	0.60	0.60	<W	<T	2.80	2.80
	Y	50	Y		1.62	<T	0.25	0.65	0.65	<W	<T	5.35	5.70

DATA QUALIFIERS					
Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.05	0.05	0.005	0.05
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

WINTER - February 1993 **CE Region**

Location	Chlorinated? (Y/N)	Dilution mL to 100	TCMP? (Y/N)	TBOD5 (mg/L)	CBOD5 (mg/L)	NH3+NH4 DAY 0	NH3+NH4 DAY 5	TKN DAY 0	TKN DAY 5	NO2 DAY 0	NO2 DAY 5	NO2+NO3 DAY 0	NO2+NO3 DAY 5
ACTON	Y	25	N	5.24	–	5.05	4.85	5.70	5.40	0.10	0.11	0.80	0.65
	Y	50	N	3.22	–	8.90	9.05	9.85	10.00	0.19	0.23	1.15	1.25
	Y	25	Y	–	3.08	5.20	5.35	5.80	6.00	0.10	0.11	0.65	0.65
	Y	50	Y	–	3.00	9.70	8.85	11.10	9.85	0.21	0.19	1.20	1.15
BARRIE	Y	25	N	5.12	–	0.80	0.80	1.15	1.05	<T	0.07	3.55	3.55
	Y	50	N	3.42	–	0.80	0.85	1.40	1.25	<T	0.07	6.95	6.60
	Y	25	Y	–	6.60	0.80	0.85	1.10	1.15	<T	<T	3.35	3.65
	Y	50	Y	–	3.42	0.80	0.90	1.35	1.35	<T	0.03	6.55	6.80
COBOURG 1	N	25	N	11.96	–	2.15	2.20	2.50	2.70	<T	0.06	0.10	<T
	N	50	N	5.18	–	3.50	3.55	4.35	4.40	0.05	0.10	0.15	0.25
	N	25	Y	–	9.24	2.15	2.40	2.60	3.00	<T	0.03	0.10	<T
	N	50.	Y	–	4.42	3.50	3.80	4.35	4.60	0.05	0.05	0.10	<T
COBOURG 2	N	25	N	15.64	–	4.05	4.10	7.75	7.75	<T	0.13	0.15	0.30
	N	50	N	10.94	–	7.10	7.40	14.10	14.20	<T	0.16	0.20	0.40
	N	25	Y	–	19.36	0.80 ?	4.50	0.85 ?	6.10	<W	<T	0.05	<T
	N	50	Y	–	13.12	7.20	7.80	14.30	14.60	<T	0.03	0.15	<T
DUFFIN CREEK	N	25	N	22.64	–	1.40	0.25	2.20	0.65	0.18	0.17	3.40	5.15
	N	50	N	14.10	–	1.95	0.70	3.00	1.40	0.35	0.66	6.50	6.10
	N	25	Y	–	8.76	1.45	1.40	2.10	1.95	0.19	0.03	3.60	3.70
	N	50	Y	–	7.58	2.05	2.10	3.05	2.60	0.37	0.05	6.95	7.25
LAKEVIEW	Y	25	N	11.96	–	3.45	3.40	4.35	4.20	0.05	0.18	1.30	1.40
	Y	50	N	6.80	–	8.20	8.05	7.75	7.50	0.11	3.15	2.60	2.80
	Y	25	Y	–	11.00	3.45	3.65	4.30	4.40	0.05	0.06	1.30	1.35
	Y	50	Y	–	5.80	6.15	6.35	7.50	7.80	0.10	0.11	2.55	2.55
MAIN	N	25	N	13.20	–	5.65	5.25	6.70	5.85	0.22	0.79	1.60	2.60
	N	50	N	12.72	–	11.30	10.40	12.60	11.90	0.45	1.34	3.30	4.90
	N	25	Y	–	8.80	5.90	6.00	6.85	7.05	0.22	0.14	1.60	1.70
	N	50	Y	–	5.04	11.50	11.40	13.10	13.20	0.46	0.24	3.35	3.55
NORWOOD	N	25	N	4.32	–	0.60	0.40	1.10	0.75	<T	0.26	3.65	4.10
	N	50	N	2.88	–	0.35	<T	1.15	0.55	0.03	0.38	9.95	8.05
	N	25	Y	–	2.04	0.80	0.65	1.15	1.00	<T	<T	3.70	3.65
	N	50	Y	–	3.50	0.45	0.50	1.15	0.95	<T	0.03	7.20	7.75
PORT HOPE	N	25	N	12.84	–	0.60	0.25	1.10	0.65	0.04	0.23	3.25	3.50
	N	50	N	7.94	–	0.45	<T	1.10	0.65	0.09	0.20	6.60	6.75
	N	25	Y	–	10.00	0.60	0.65	1.10	1.05	0.04	0.04	3.15	3.35
	N	50	Y	–	6.40	0.45	0.40	1.15	0.90	0.08	0.06	6.60	6.65
SKY WAY	N	25	N	6.64	–	5.30	4.80	5.65	5.30	0.36	0.68	0.70	1.10
	N	50	N	7.82	–	9.70	8.45	10.70	9.20	0.72	1.43	1.30	2.30
	N	25	Y	–	3.88	5.45	5.10	6.10	5.60	0.37	0.32	0.65	0.65
	N	50	Y	–	3.04	9.70	9.90	10.70	10.70	0.72	0.61	1.25	1.30
OAKVILLE S/E	N	25	N	4.98	–	2.70	2.65	3.30	3.05	0.03	0.14	1.80	2.00
	N	50	N	3.30	–	4.56	4.40	5.25	5.05	0.06	0.29	3.50	4.15
	N	25	Y	–	2.92	2.80	2.90	3.30	3.30	0.03	0.03	1.85	1.95
	N	50	Y	–	1.02	5.10	5.05	5.75	5.70	0.07	0.06	4.00	4.05
OAKVILLE S/W	N	25	N	13.28	–	3.30	2.60	4.00	3.30	0.07	0.37	<T	0.65
	N	50	N	10.28	–	6.50	5.35	7.60	6.45	0.16	0.69	0.45	1.50
	N	25	Y	–	5.96	3.40	3.65	4.10	4.20	0.07	0.07	0.25	0.25
	N	50	Y	–	7.06	6.60	6.40	7.90	7.40	0.15	0.12	0.45	0.55
STOUFFVILLE	N	25	N	3.96	–	1.35	1.15	1.65	1.45	0.04	0.29	2.70	3.10
	N	50	N	3.98	–	1.65	1.40	2.45	1.65	0.08	0.52	5.25	5.80
	N	25	Y	–	0.84	1.35	1.35	1.70	1.70	0.04	0.04	2.80	2.65
	N	50	Y	–	1.32	1.90	1.90	2.35	2.35	0.08	0.08	5.40	5.60
SUTTON	N	25	N	3.88	–	2.60	2.55	3.05	2.95	0.15	0.17	1.45	1.45
	N	50	N	2.98	–	4.45	4.45	5.45	5.10	0.30	0.41	2.95	3.20
	N	25	Y	–	2.04	2.55	2.60	3.15	3.15	0.15	0.15	1.45	1.50
	N	50	Y	–	1.88	4.50	4.50	5.35	5.30	0.31	0.31	3.00	3.05

Parameter	BOD5	NH3+NH4	TKN	NO2	NO2+NO3
Unit	mg/l as O	mg/l as N	mg/l as N	mg/l as N	mg/l as N
W	0.2	0.06	0.06	0.005	0.06
T	1.0	0.25	0.25	0.025	0.25
?	Unreliable result, please ignore				
N/A	Not Available				
ICR	Could not repeat analysis to confirm result				
RO	Run-out				

WINTER - February 1993 WC Region

Location	Chlorinated?	Dilution	TCMP?	TBOD5	CBOD5	NH3+NH4		TKN		NO2		NO2+NO3	
	(Y/N)	mL to 100	(Y/N)	(mg/L)	(mg/L)	DAY 0	DAY 5	DAY 0	DAY 5	DAY 0	DAY 5	DAY 0	DAY 5
BRANTFORD	N	25	N	5.96	–	1.85	1.90	2.50	2.35	0.10	0.16	1.75	1.80
	N	50	N	3.70	–	2.65	2.95	3.75	3.75	0.19	0.39	3.30	3.75
	N	25	Y	–	6.88	1.80	1.95	2.45	2.35	0.10	0.11	1.65	1.75
	N	50	Y	–	2.58	2.95	3.00	3.95	3.85	0.20	0.21	3.40	3.35
	Y	25	N	8.20	–	1.75	1.85	2.35	2.40	0.10	0.18	1.70	1.85
	Y	50	N	6.22	–	2.80	2.80	3.70	3.55	0.20	0.40	3.35	3.65
	Y	25	Y	–	7.16	1.85	3.00	2.40	2.40	0.11	0.11	1.80	1.80
	Y	50	Y	–	5.48	2.80	3.00	3.70	3.85	0.21	0.22	3.45	3.55
CAYUGA	N	25	N	8.00	–	0.60	0.45	1.05	0.85	<T	0.18	4.65	4.85
	N	50	N	3.36	–	0.45	<T	1.05	0.85	0.03	0.32	9.55	9.65
	N	25	Y	–	3.80	0.60	0.65	1.00	1.00	<T	<T	4.55	4.55
	N	50	Y	–	1.68	0.40	0.50	0.95	0.95	0.03	<T	9.70	9.80
	Y	25	N	5.48	–	0.60	0.65	1.00	1.00	<T	<T	4.60	4.55
	Y	50	N	2.00	–	0.45	0.50	1.00	0.90	<T	<T	9.65	9.60
	Y	25	Y	–	6.64	0.60	0.85	1.05	1.00	<T	<T	5.10	4.90
	Y	50	Y	–	2.26	0.45	0.45	1.05	1.00	<T	<T	9.45	9.55
ELORA	N	25	N	10.28	–	3.05	2.85	3.45	3.20	0.06	0.27	2.05	2.20
	N	50	N	7.46	–	5.40	4.85	6.00	5.10	0.12	0.70	4.10	4.75
	N	25	Y	–	7.88	3.10	3.15	3.85	3.45	0.06	0.06	2.05	2.05
	N	50	Y	–	3.94	5.20	5.45	5.45	5.85	0.11	0.11	3.90	4.10
	Y	25	N	11.28	–	3.05	3.20	3.50	3.60	0.05	0.06	2.00	2.06
	Y	50	N	3.94	–	5.25	5.20	5.75	5.45	0.09	0.10	3.85	3.75
	Y	25	Y	–	5.52	3.10	3.20	3.60	3.50	0.05	0.06	2.00	2.00
	Y	50	Y	–	3.30	5.50	5.35	6.00	5.80	0.10	0.10	4.10	3.90
HESPELER	N	25	N	12.2	–	0.70	0.30	1.25	0.75	0.10	0.46	3.80	4.15
	N	50	N	7.54	–	0.60	<T	1.65	0.80	0.18	0.62	7.50	8.30
	N	25	Y	–	8.44	0.70	0.70	1.35	1.10	0.09	0.14	3.70	3.95
	N	50	Y	–	5.24	0.65	0.65	1.40	1.25	0.17	0.25	7.85	7.50
	Y	25	N	11.46	–	0.70	0.60	1.25	1.05	0.09	0.32	3.60	4.10
	Y	50	N	8.20	–	0.65	0.50	1.50	1.15	0.18	0.49	8.10	8.05
	Y	25	Y	–	9.64	0.70	0.80	1.40	1.20	0.09	0.11	3.85	3.70
	Y	50	Y	–	6.98	0.65	0.80	1.70	1.60	0.18	0.22	7.85	7.60
SHELBURNE	Y	25	N	18.06	–	0.70	0.65	1.15	1.05	0.98	1.02	4.70	4.65
	Y	50	N	10.06	–	0.60	0.70	1.25	1.20	1.94	1.96	9.45	9.15
	Y	25	Y	–	16.32	0.70	0.75	1.15	1.15	0.97	0.85	4.70	4.65
	Y	50	Y	–	11.18	0.80	0.70	1.20	1.15	1.84	1.60	8.95	9.20
ST.JACOBS	N	25	N	5.00	–	0.95	0.90	1.35	1.30	0.03	0.13	4.55	4.60
	N	50	N	4.58	–	1.10	0.70	1.50	1.25	0.06	0.38	8.70	9.35
	N	25	Y	–	3.72	0.90	1.00	1.35	1.35	0.03	0.03	4.45	4.30
	N	50	Y	–	3.22	1.05	1.15	1.55	1.55	0.05	0.06	9.15	9.05
	Y	25	N	4.32	–	0.85	0.90	1.30	1.20	<T	0.03	4.40	4.55
	Y	50	N	3.46	–	0.90	1.00	1.65	1.55	0.03	0.04	8.75	8.50
	Y	25	Y	–	4.52	0.85	0.90	1.30	1.30	<T	<T	4.45	4.35
	Y	50	Y	–	3.66	0.90	1.05	1.50	1.40	0.03	0.04	9.00	9.35